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CONCEPTUAL DESIGN REPORT FOR OPERABLE UNIT 5 SOIL REMEDIATION VOLUMES 1 & 2 - (USED AS A REFERENCE IN OU2 FS)

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REPORT

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Conceptual Design Report
for
Operable Unit 5 Soil Remediation
Volume I

CERCLA/RCRA Unit 5
Project Order 81
November 1993
Revision A

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio
FERMCO Subcontract No. 2-21487

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Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

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LIST OF ACRONYMS AND ABBREVIATIONS

ACA	Amended Consent Agreement
ACI	American Concrete Institute
ALARA	As Low As Reasonably Achievable
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
AWWT	Advanced Wastewater Treatment
CDR	Conceptual Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CRU	CERCLA RCRA Unit
CSF	Central Storage Facility
CY	cubic yards
DCR	Design Criteria Report
D&D	Decontamination and Decommissioning
DOE	United States Department of Energy
ERMA/GIS	Environmental Resource Management Analysis/Geologic Information System
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
ID	Integrated Demonstration
LDR	Land Disposal Restriction
MAWS	Minimum Additive Waste Stabilization
M&E	Materials and Equipment
NFPA	National Fire Protection Association
OBBC	Ohio Basic Building Code
Ohio EPA	Ohio Environmental Protection Agency
OU	Operable Unit
PCB	Polychlorinated Biphenyl
pCi	Picocuries
PFD	Process Flow Diagram
PO	Project Order
ppm	parts per million
PQAP	Project Quality Assurance Program
QL	Quality Level
RA	Remedial Action
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

RD	Remedial Design
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SA	Safety Assessment
SAR	Safety Analysis Report
SCQS	Soil Characterization and Quantification Study
SRSS	Soil Remediation Schedule Study
TBC	To Be Considered
TER	Technical Evaluation Report for the Site Integrated Soil Washing System
TPH	Total Petroleum Hydrocarbons
UBC	Uniform Building Code
UCRL	University of California Research Laboratory
US EPA	United States Environmental Protection Agency
UST	Underground Storage Tank
U-total	Total Uranium
WBS	Work Breakdown Structure

EXECUTIVE SUMMARY

This section summarizes the salient points that provide the project description, background, need, cost, and schedule. The leading remedial alternative will be discussed, with reference to other alternatives provided. In addition, any areas requiring further study will be summarized. This section will be completed for subsequent submittals of this Conceptual Design Report.

SECTION 1

PROJECT DESCRIPTION

This Conceptual Design Report (CDR) presents the conceptual design of the Fernald Environmental Management Project (FEMP) Operable Unit 5 (OU-5) soil remediation project. This document summarizes the conclusions and recommendations reached as a result of the conceptual design process and provides the United States Department of Energy (DOE) the information necessary to forecast and secure funding for the project. This CDR was prepared in accordance with the draft Conceptual Design Report Preparation Guide, Revision 1, dated January 1992, as amended in the Project Order (PO) Plan for PO-81, Revision 1, dated October 1993.

The purpose of this section is to: provide background information on soil contamination at the FEMP; introduce the project; provide an overview of the project's purpose and scope; substantiate the need for the project; and discuss the leading remedial alternative.

1.1 Background

During approximately 38 years of uranium refinery operations (1951-1989), FEMP soils received varying levels of contamination from airborne deposition. In addition, leaks and spills from processing activities within the former production area have resulted in soil contamination.

According to the *Initial Screening of Alternatives for Operable Unit 5* (DOE 1992a), FEMP soils contain primarily radiological contaminants. Uranium is the indicator parameter for contamination at the FEMP. Other inorganic constituents, including radionuclides and metals, and organics are present. Currently, no promulgated standards exist for radiological contamination levels in soil (other than radium). For the purpose of this CDR, a preliminary remediation goal of 35 pCi/g is **assumed**. This action level is not intended to supplant the Remedial Action Objectives (RAOs) established under the United States Environmental Protection Agency (US EPA)-issued Record of Decision (ROD) for OU-5. However, this action level is consistent with levels proposed by the Nuclear Regulatory Commission in its branch technical position paper, "Disposal or On-Site Storage of Residual Thorium or Uranium (Either as Natural Ores or Without Daughters Present) from Past Operations," published in the Federal Register on October 23, 1981, and proposed 10 Code of Federal Regulations (CFR) 834.

During the remediation of each FEMP OU, large quantities of contaminated soil will be excavated. These contaminated soils must be remediated in accordance with RAOs established under each OU's ROD.

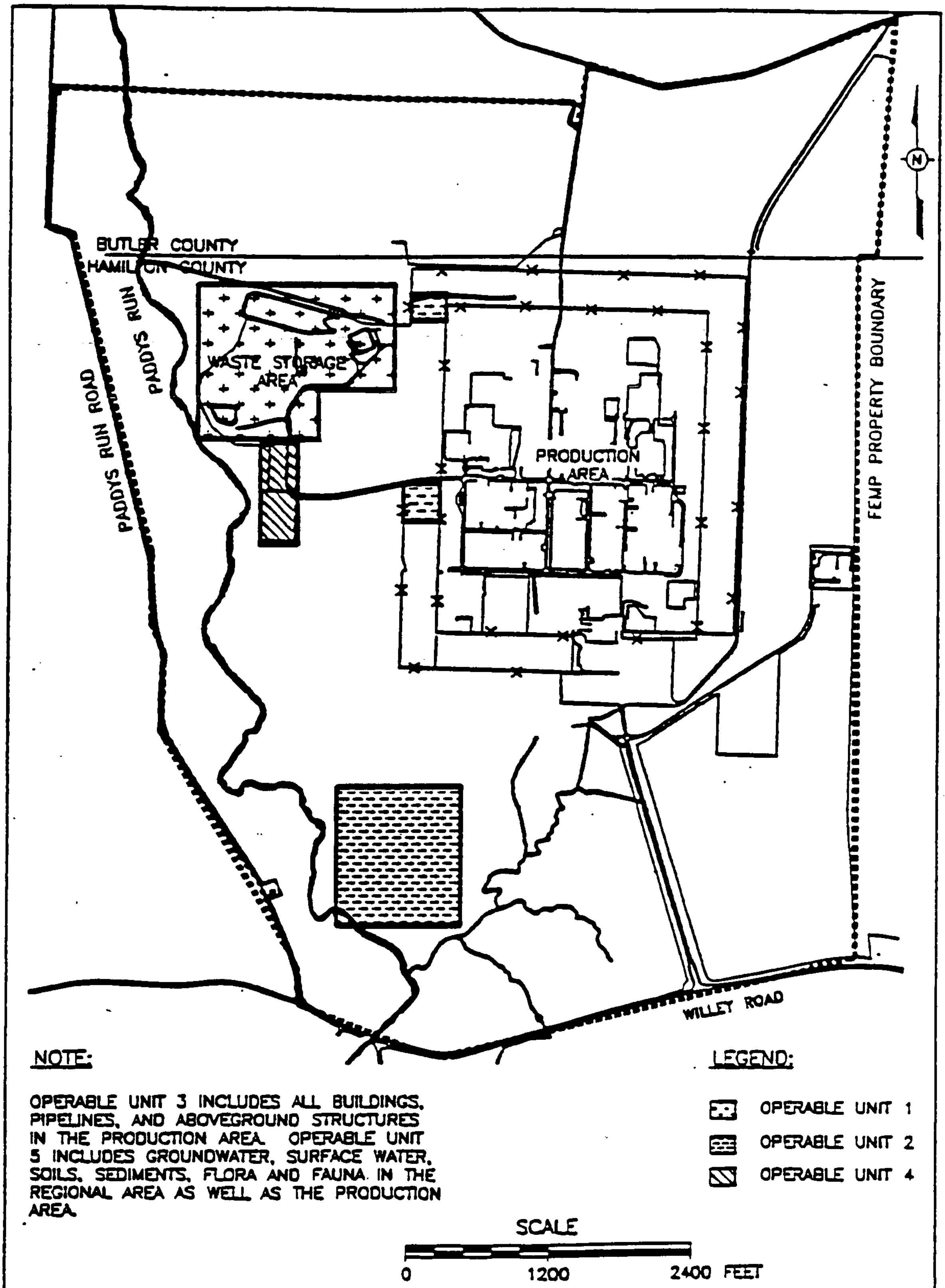
The *Initial Screening of Alternatives for Operable Unit 5* (DOE 1992a) identified several technologies and process options considered potentially applicable for the remediation of FEMP soils. Among the treatment processes considered was soil washing. Soil washing is a treatment technology designed to remove contaminants from soil by either dissolving the contaminants in wash solutions, suspending the contaminants in wash solutions, incorporating simple particle size separation techniques, or any combination of these. According to the *Treatability Study Work Plan for Operable Unit 5 Soil Washing* (DOE 1992b), a literature review revealed that water washing with extractive agents has been successfully used on soil contaminated with radionuclides. However, information was not found on its applications to soils containing radionuclides, in addition to inorganics and organics, which characterizes the OU-5 soils. Therefore, a decision was made to proceed with treatability testing of the soil washing process. Soil treatability studies are currently being conducted by the Fernald Environmental Restoration Management Corporation (FERMCO) CERCLA/RCRA Unit 5 (CRU-5) and the DOE Integrated Demonstration (ID) Program. Preliminary results from these soil treatability studies form part of the technical basis for this CDR.

OU-5 is comprised of the FEMP area environmental media including groundwater, surface water, soil not included in the definitions of OUs 1, 2, and 4, sediments, flora and fauna. OU-5 soils include all those soils not within the specifically identified boundaries of OUs 1, 2, and 4 (Figure 1-1). All the production area (OU-3) soils are included in OU-5. In addition, contaminated soils outside the FEMP boundary are the responsibility of OU-5.

1.2 Introduction

FERMCO proposes to construct a soil washing facility which will treat contaminated soil from all the FEMP OUs. Contaminated soils will be excavated, transported to the treatment facility, treated for the removal of contaminants, and stored temporarily until they are reused at the FEMP (e.g., for unclassified backfill).

FERMCO CRU-5 is responsible for the overall integration of FEMP soil remediation activities. CRU-5 will excavate contaminated soils outside of OUs 1, 2, and 4, and transport them to the soil washing facility. Other FERMCO CRUs are responsible for excavating contaminated soils from OUs 1, 2, and 4, and transporting them to and from the soil washing facility. CRU-5 will operate the soil washing facility and stockpile treated soils prior to their reuse on site. CRU-5 will transport the dirty soil fraction remaining after treatment and the contaminant residues from the soil washing facility to a subsequent FEMP facility for treatment, storage, or disposal.



(Figure excerpted from the Initial Screening of Alternatives For Operable Unit 5, January 1992)

Figure 1-1 - FEMP Operable Unit Boundaries

It is assumed that soil washing wastewater will be recycled to the extent possible. However, a small bleed wastewater stream will be transported to the Advanced Wastewater Treatment (AWWT) facility for treatment. Soil washing process water makeup will be provided by the AWWT. In addition, it is assumed that interim storage of some contaminated soils will be provided by the proposed Central Storage Facility (CSF). However, the CSF is intended to store only those soils exceeding 100 pCi/g total uranium, 50 pCi/g total thorium, or 5 pCi/g total radium, and has a limited storage capacity of approximately 13,500 cubic yards (CY). It is assumed that additional interim storage of contaminated soils will be provided adjacent to the soil washing facility. Figure 1-2 is a location map showing the proposed location of the soil washing facility in relation to the AWWT facility and the CSF.

1.3 Overview and Project Scope

The following subsections describe the purpose of the OU-5 Soil Remediation project and provide a summary of the scope of work for the CDR.

1.3.1 Overview

The purpose of this project is to prepare a conceptual design of the facilities and systems required to perform the following activities:

1) Handle contaminated soils, including; the excavation of contaminated soils from OUs 3 and 5, monitoring of excavated soils, transportation of excavated soils, stockpiling of excavated soils prior to treatment, and transporting stockpiled soils to the treatment facility.

2) Treat contaminated soils for the removal of uranium in accordance with the RAOs established under the OU-5 ROD.

3) Handle treated soils, including; transporting treated soils to a clean soil stockpile, stockpiling clean soils, and transporting clean soils to a final disposition site at the FEMP.

4) Handle wastes generated during the excavation and treatment of contaminated soils, including; unwashable soils, concentrated contaminant residues, the contaminated soil fraction remaining after treatment, process wastewaters.

5) Provide utility system support to the soil washing system.

Current soil treatability testing programs will determine the choice of chemical extractants and leachates to be used in the soil washing process.

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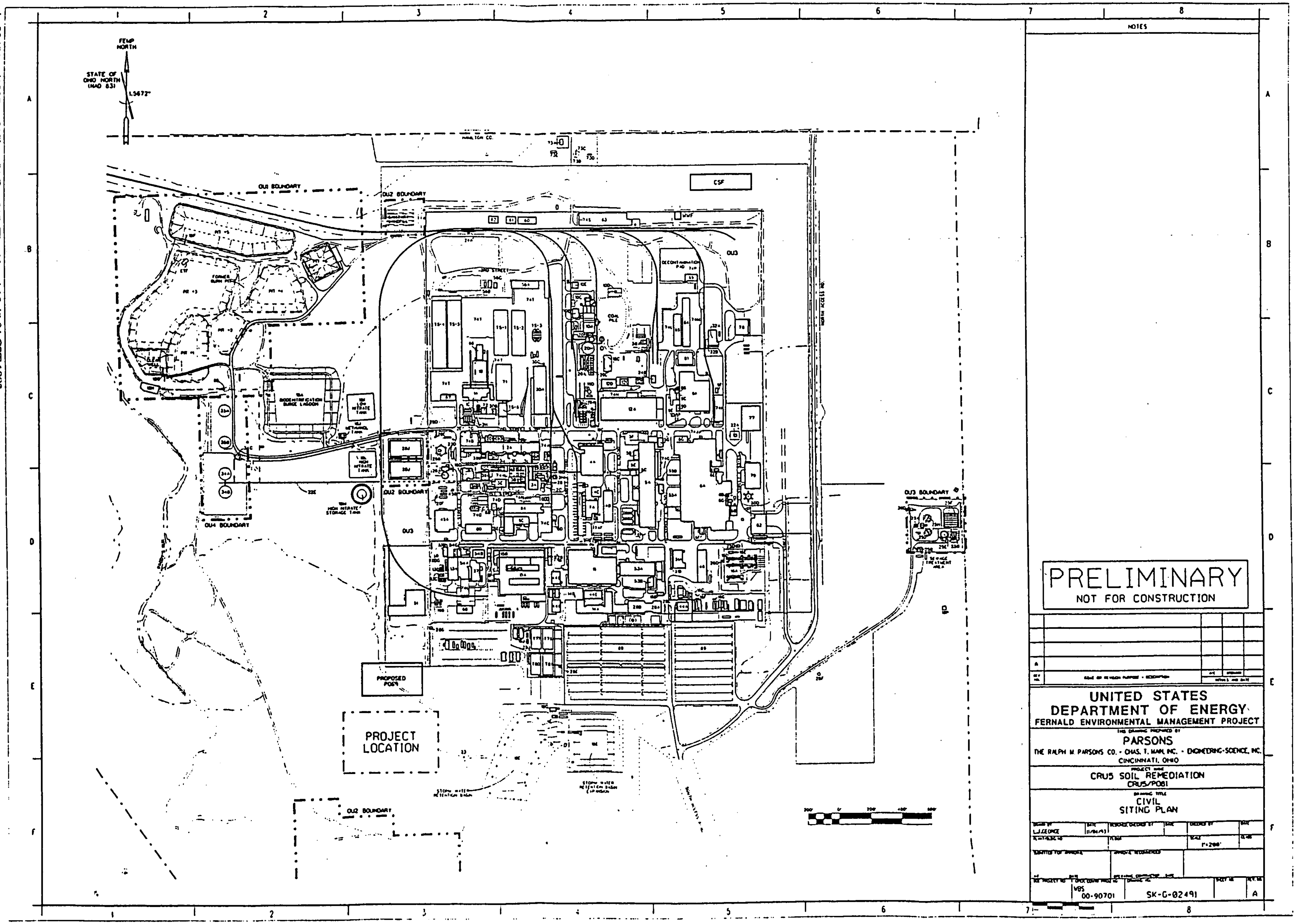

Figure 1-2 - Soil Washing Project Location Map

Additional future engineering studies will be discussed in subsequent submittals of this CDR.

1.3.2 Project Scope

The scope of work for this CDR was provided in FERMCO PO-81, Revision 1, and is included in Volume II, Attachment A. The significant components of the soil remediation project scope include:

1) Contaminated soil excavation, monitoring, transportation, and stockpiling
2) Contaminated soil treatment
3) Clean soil transportation and stockpiling
4) Secondary waste handling
5) Utility system support

1.3.2.1 Contaminated Soil Handling

The *Soil Characterization and Quantification Study* (SCQS) (contained in Volume II, Attachment C) provides an estimate of the types of contaminants and quantity of contaminated soils contained in each FEMP OU. The SCQS determined that the distribution of contaminants in FEMP soils are often similar. This suggests that removing the volume of soil contaminated with a key constituent results in the removal of soils contaminated with other constituents as well. It is **assumed** that U-total is the key constituent in FEMP soils. Based on available soil monitoring data, the SCQS determined that there is approximately 604,000 cubic yards of soil at the FEMP which is contaminated with U-total at levels exceeding the 35 pCi/g remediation goal. However, due to a lack of soil monitoring data for subsurface soils, especially in OU-4, the SCQS estimate is considered to be a lower limit of the volume of contaminated soil.

Each FERMCO CRU has developed an estimate of the contaminated soil volumes contained in their respective OUs. These FERMCO estimates are primarily based upon the physical characteristics of each remedial element and assumptions as to the depth of contamination. As part of the *Soil Remediation Schedule Study* (SRSS) (contained in Volume II, Attachment D), the SCQS estimates were compared to each of the FERMCO estimates and a conservative estimate of contaminated soil volumes developed. Table 1-1 presents a comparison of SCQS and FERMCO estimates, and the conservative estimate used for the SRSS.

Table 1-1 - Contaminated Soil Volumes (In Cubic Yards)

Operable Unit	SCQS Estimate	FERMCO Estimate	Conservative Estimate
1	128,000	294,500	294,500
2	28,000	85,850	85,850
3	428,000	900,000	900,000
4	0	29,629	29,629
5*	20,000	36,300	56,300
Total	604,000	1,346,279	1,366,279

* Note: The SCQS Estimate for OU-5 does not include existing controlled soil stockpiles. The FERMCO Estimate does not include in situ OU-5 soils. The Conservative Estimate for OU-5 includes both controlled soil stockpiles and in situ OU-5 soils.

The contaminated soil volume estimates were used along with the most current OU remediation schedules to prepare a recommended FEMP soil remediation strategy. The SRSS determined that approximately 1.4 million CY (approximately 2.4 million tons) of contaminated soil require treatment. The results of the SRSS were used to determine the capacity of the proposed soil washing system.

The SCQS contaminated soil volume estimate of 604,000 CY may be considered a lower limit and the SRSS Conservative Estimate of 1,366,270 CY may be considered an upper limit. Section 3 of this CDR will provide a comparison of the costs of treating the lower and upper limits of contaminated soil volumes.

The Material Handling Plan will be based upon the results of the SCQS, the SRSS, the *Technical Evaluation Report for the Site Integrated Soil Washing System* (TER) (included in Volume II, Attachment E), and the following considerations:

1) Feed requirements of the soil washing system

2) Stockpile capacities (contaminated and clean soil stockpiles)

3) Size and shape of the areas to be excavated

4) OU remediation schedules (i.e., the OU-3 Decontamination and Decommissioning [D&D] schedule)

5) Production rates of the excavation equipment to be employed

6) Decontamination requirements of mobile equipment

7) Soil types excavated

8) Stormwater run-off control in active excavations

The plan will provide effective planning and scheduling of the excavation of each OU, and optimize the size and make-up of the material handling equipment fleet. The plan will provide the following documents which will be included in subsequent submittals of the CDR:

1) Material flow diagrams

2) Typical excavation cross sections illustrating soil excavation, soil placement and stormwater run-off control measures

3) A CDR section detailing the requirements of soil excavation, soil placement, and containerizing and handling of soil residues.

1.3.2.2 Soil Treatment

The TER provides an overview of soil washing as a viable treatment technology for use on FEMP site soils. The following soil washing systems were evaluated in the TER:

1) Mineral acids
2) Citrate-bicarbonate-dithionite with ammonium carbonate
3) Citric acid/citrate
4) Bisequential citric acid/carbonate
5) Sodium carbonate/bicarbonate

All of the above systems were able to reduce the uranium concentration in the soil below the remediation goal of 35 pCi/g. However, the TER recommended sodium carbonate/bicarbonate as the scrubbing/ extracting solution for the proposed soil washing system. The following subsection briefly describe the results of the evaluation of each system:

Mineral Acid

Leaching of soil by mineral acid was more destructive to soil constituents, particularly aluminosilicate clay minerals. This produces large volumes of sludge during the precipitation of uranium from the leachate. The production of this sludge is an additional waste form requiring treatment. Also large volumes of acid are used in dissolution of carbonate minerals, namely calcite and dolomite. Such reactions do not occur in alkaline leach involving sodium carbonate extractions.

Citrate-Bicarbonate-Dithionite With Ammonium Carbonate

Citrate-bicarbonate-dithionite with ammonium carbonate leaching also produced some sludge. In addition, leaching for this system must take place at high temperatures (75 to 80 degrees C). Sulfates precipitate from the leaching solution and entrain the uranium upon cooling to ambient, meaning that filtration must happen quickly after leaching at high temperatures. The citrate forms soluble complexes with the iron and aluminum which reduces the citrate's capacity to complex uranium plus 4 valence (uranium plus 4 valence cannot be extracted because it precipitates out as a hydrated oxide). Another disadvantage is that the quantities of citrate and dithionite required during testing were high, which would mean high operating costs.

Citric Acid/Citrate

Citric Acid/citrate leaching removes significant quantities of iron, aluminum, calcium, and magnesium from the soil. The quantity of the acid needed to treat the soil is high due to dissolution of carbonate minerals, namely calcite and dolomite. This creates a high volume of sludge and associated complex waste disposal scenarios. Also, both the quantity of acid required, and the leach time (4 hours) are high.

Bisequential Citric Acid/Carbonate

The citric acid/carbonate extraction is a three stage process; Stage 1 involves leaching with citric acid, Stages 2 and 3 involve leaching with sodium carbonate. This obviously is more complex than a single stage extraction involving acidic or alkaline leach. Citric acid is not economically produced in large quantities. In addition, the process complexity will result in higher capital equipment and operating costs.

Sodium Carbonate

Sodium carbonate selectively leaches uranium from the soil, and does not destroy the aluminosilicate minerals to the extent as the mineral acids. Therefore it does not generate a high amount of secondary waste. The tetravalent uranium is oxidized to hexavalent uranium at a faster rate compared to acid solutions, and the uranium plus 6 valence is readily leachable with sodium carbonate. A leach time of 2 hours is required because of slow reaction kinetics at a leach temperature between 40 to 60 degrees C.

Figure 1-3 provides a block flow diagram for the proposed soil washing system. The proposed soil washing process is shown in greater detail in the Process Flow Diagrams (PFDs) included in Volume II, Section 3. The soil washing process is designed to receive and process a nominal 12.5 tons/hr of soil, and will operate 7 days per week, 24 hours per day. The soil washing system incorporates a combination of physical separation and chemical extraction techniques in order to separate uranium (the primary contaminant) from the contaminated soil. Once separated, the resultant clean soil is returned to the site as backfill, and the contaminated fraction is sent for further treatment (such as vitrification or cementation) and/or disposal. The following unit operations are involved in the proposed soil washing system:

1) Material handling
2) Screening
3) Drum washing
4) Flocculation
5) Thickening
6) Leaching
7) Filtration
8) Precipitation
9) Reagent receipt and handling

Material Handling

The material handling diagrams and operating philosophy are being developed and will be included in subsequent submittals of this CDR.

Screening, Drum Washing, Flocculation, and Thickening

The screening, drum washing, flocculation, and thickening operations are shown in detail in Sketch No. SK-F-02107 included in Volume II, Section 3. A front-loader is used to transfer the excavated soil from the enclosed contaminated soil storage to a feed conveyor via a feed hopper. This conveyor feeds the soil to a vibrating bar grizzly with a 6-inch opening. The oversize material from the vibrating grizzly is transferred to the secondary drum washer where it is water washed. The undersize material from the vibrating bar grizzly is sent to the primary drum washer, with a 1/2-inch trommel screen at its outlet, where the soil is water washed. The plus 1/2-inch material is sent to the secondary drum washer, and the minus 1/2-inch material is sent to a vibrating double deck screen for wet screening using water sprays. This vibrating double deck screen has a 4 mesh lower screen and a 3/4-inch protective top screen. The plus 4 mesh material from the double deck screen is transferred to the secondary drum washer. The secondary drum washer has a 4 mesh trommel screen at its outlet. The plus 4 mesh water washed material is returned to the site as clean soil after verification, and the minus 4 mesh water washed material is returned to the double deck screen.

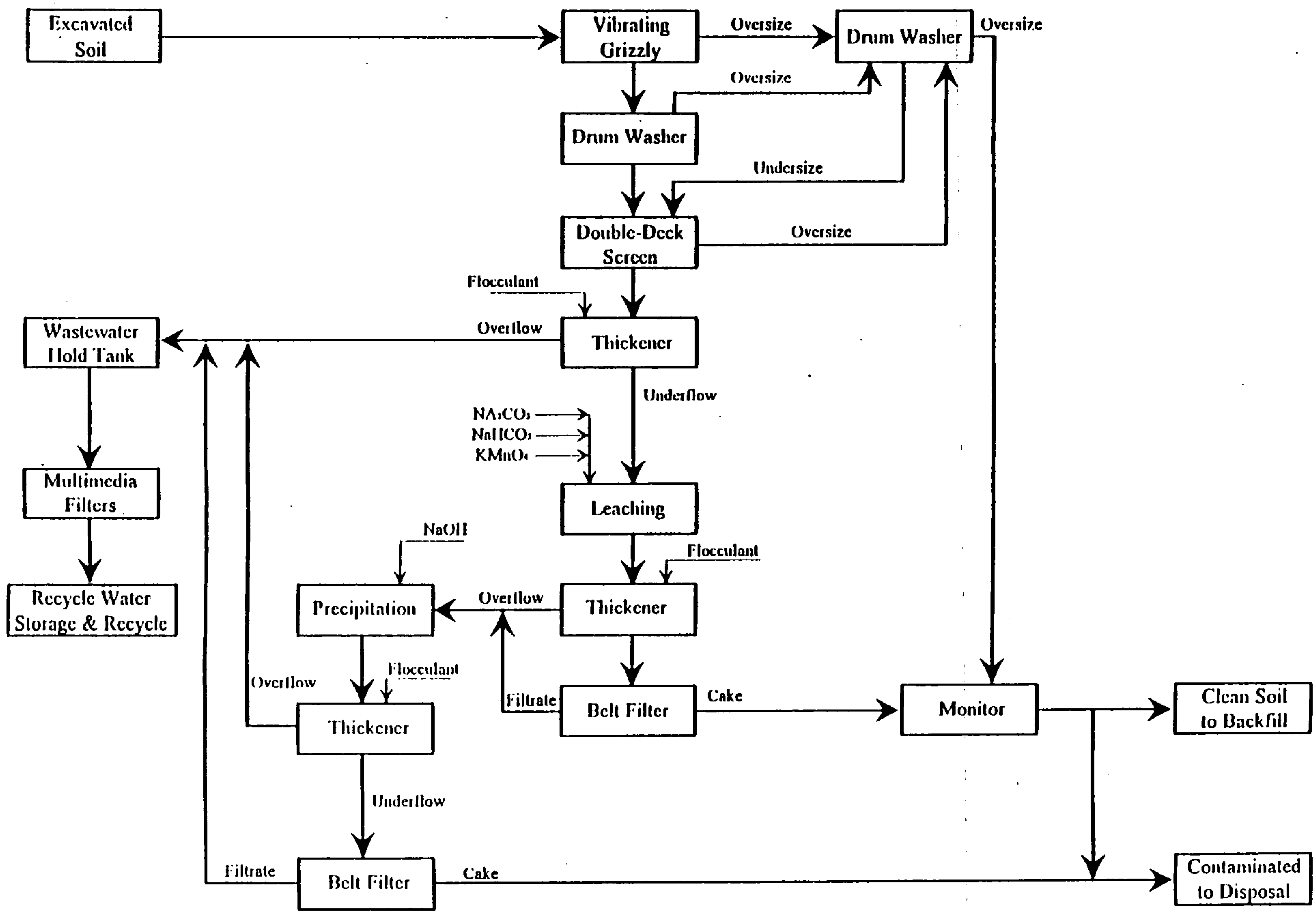

Figure 1-3 - Proposed Soil Washing System Block Flow Diagram

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The minus 4 mesh material from the double deck screen is sent to the primary thickener where flocculant is added to aid in the settling process. The flocculant is received in 55 gallon drums. The flocculant is metered from the drums to the flocculant make-up tank where it is mixed with enough process water to form a 0.1 percent flocculant solution.

The thickener overflow is sent to a sump from where the overflow is pumped to the wastewater hold tank. The thickener underflow (35 percent solids) is pumped to the leaching process.

Leaching

The leaching and filtration operations are shown in detail in Sketch No. SK-F-02108 included in Volume II, Section 3. The 35 percent solids underflow from the primary thickener is received in the first in a series of three agitated reactor scrubbers. These reactor scrubbers act as combination attrition scrubbers and leach tanks. Attrition scrubbing is done to abrade and separate the smaller uranium particles from the larger clean soil particles, and leaching is done to remove the uranium from the soil and put it into solution. The reagents sodium carbonate/bicarbonate and potassium permanganate are added to the first reactor scrubber along with the 35 percent soil slurry. This process is designed to take place at a temperature of 40 degrees C. Therefore, steam is added to each of the reactor scrubbers in order to raise and maintain the temperature of the scrubbing/leaching solution. The reactor scrubbers have a total residence time of 2 hours.

After leaving the reactor scrubbers, the slurry is pumped to the leach thickener where flocculant is added to aid in the settling process. The overflow from the leach thickener is sent to a sump from where the overflow is pumped to the precipitation process. The leach thickener underflow (50 percent solids) is pumped to the leach belt filter holding tank, which feeds the leach belt filter. The filter cake is washed with process water before discharge and is then discharged at approximately 75 percent solids level. This cake is considered as clean soil and is returned to the site for backfill after verification. The filtrate from the belt filter is collected in three separate zones (typical). The filtrate from the first zone near the beginning of the belt filter is expected to contain dissolved contaminants. Therefore, it is pumped to the precipitation process. The filtrates from the last two zones are recycled back to the belt filter and help in washing the filter cake progressively, the final wash being with process water.

Precipitation

The precipitation operation is shown in detail in Sketch No. SK-F-02109 included in Volume II, Section 3. The overflow from the leach thickener and the filtrate from the leach belt filter are received in the first of a series of two precipitation tanks along with the precipitation reagent sodium hydroxide. Precipitation is performed in order to make the leached uranium insoluble, thereby bringing the uranium out of solution in solid form. The precipitation tanks have a total residence time of 1 hour which allows ample time for all reactions to occur.

After leaving the precipitation tanks, the slurry is sent to a regeneration tank where CO_2 is introduced to react with the remaining sodium hydroxide, yielding sodium carbonate and water. From the regeneration tank, the slurry is pumped to the precipitate thickener where flocculants are added to aid in the settling process. The overflow from the precipitate thickener is sent to a sump from where the overflow is pumped to the wastewater hold tank. The precipitate thickener underflow (35 percent solids) is pumped to the precipitate belt filter holding tank, which feeds the precipitate belt filter. The filter cake is washed with process water before discharge and is then discharged at a 70 percent solids level. This cake is considered as contaminated and is sent on to further treatment and/or disposal. The filtrate from the precipitate belt filter is pumped to the wastewater hold tank.

The collected quantities in the wastewater hold tank are pumped through multi-media filters in order to remove particulate matter. The effluent from the multi-media filters is transferred to the recycle water storage tank. This water is recycled to the primary drum washer and the double deck screen. A portion of the recycle water is bled to the AWWT facility.

Potassium permanganate ($KMnO_4$) is received as a dry material in bags. The dry potassium permanganate is hand-dumped into the potassium permanganate make-up tank and mixed with process water to form solution.

Reagent Receipt and Handling

The reagent receipt and handling operations are shown in detail in Sketch No. SK-F-02110 included in Volume II, Section 3. The sodium bicarbonate, sodium carbonate, and caustic soda reagents are supplied to the soil washing facility via tank trucks.

Sodium bicarbonate and sodium carbonate are brought in as dry materials and are unloaded to their respective storage silos. From the storage silos, these reagents are pneumatically conveyed to their respective day bins, from where they are conveyed to the process at predetermined rates.

Caustic soda is supplied to the soil washing facility as liquid in the form of 50 percent NaOH solution. The caustic soda is pumped from the tank truck to the caustic soda storage tank. From the storage tank, caustic soda is transferred to a day tank, from which the process is supplied.

Facility Type and Siting

The TER also evaluated whether the soil washing system should be a single, centrally located facility, or multiple portable systems. The TER recommended the soil washing project be a single, centrally located facility with multiple process trains.

In addition, the TER also evaluated alternative project sites for a central soil washing facility. A 7-acre parcel south of the proposed AWWT-Phase III facility was recommended as the project site because the cost to extend utilities to the project site and prepare the site for construction was determined to be the lowest among the alternatives evaluated. In addition, the vehicle fleet size required to maintain the remediation schedule is equal to, or smaller than, the alternative project sites.

1.3.2.3 Clean Soil Handling

The clean soil fraction remaining after treatment must be transported from the soil washing system to a clean soil stockpile. A more detailed description of treated soil handling will be provided as part of the Material Handling Plan and included in subsequent submittals of the CDR.

1.3.2.4 Secondary Waste Handling

The soil remediation project will generate several types of secondary waste, including: unwashable soils, concentrated contaminant residue, the contaminated soil fraction remaining after treatment, and process wastewater. A more detailed description of secondary waste handling will be provided as part of the Material Handling Plan and included in subsequent submittals of the CDR.

1.3.2.5 Utility System Support

A detailed description of the utility support requirements, and proposed expansions/additions to the FEMP utility systems will be included in subsequent submittals of the CDR. In addition, proposed changes to the FEMP road system will be included in subsequent submittals of the CDR.

1.3.3 Design and Construction Work Packages

To prepare the required engineering documents and to perform the associated construction in a manageable sequence, four design and construction work packages have been developed to complete the remediation effort. These packages include:

1) Site Preparation, Utilities and Security

2) Material Handling Systems and Facilities
    - (1) Contaminated Soil Excavation and Monitoring
    - (2) Contaminated Soil Handling Systems
    - (3) Contaminated Soil Stockpile
    - (4) Clean Soil Handling Systems
    - (5) Clean Soil Stockpile

3) Soil Washing System and Facilities

4) Secondary Waste Handling Systems and Facilities
   (1) Unwashable Soil Handling
   (2) Contaminated Soil Fraction Handling
   (3) Concentrated Contaminant Residue Handling
   (4) Process Wastewater Handling

The scopes of work for each of these work packages will be described in further detail in Section 1 of Volume II.

1.4 Justification

In March 1985, the US EPA issued a Notice of Noncompliance letter to the DOE identifying the US EPA's concerns regarding environmental impacts associated with past operations which occurred at the FEMP. In July 1986, a Federal Facility Compliance Agreement (FFCA) was signed by the DOE and US EPA under authority of Executive Order 12088. The FFCA addresses the prevention, control, and abatement of environmental pollution at the FEMP site. In November 1989, the FEMP was added to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List. Pursuant to the authorities under CERCLA Sections 120 and 106(a), the DOE and the US EPA entered into a Consent Agreement in April 1990 for remediating the FEMP under the provisions of CERCLA. This 1990 Consent Agreement identified the FEMP OUs. In September 1991, the Consent Agreement was amended to allow schedule relief. The Notice of Noncompliance, the FFCA, and the Amended Consent Agreement (ACA) form the regulatory basis for remediating the soil under the provisions of CERCLA. These agreements also influence the schedule for soil remediation. A Proposed Draft ROD specifying the leading remedial alternatives for OU-5 is due to be submitted to the US EPA by July 2, 1995.

According to the *Treatability Study Work Plan for Operable Unit 5 Soil Washing* (DOE 1992a), large portions of the FEMP production area currently have U-total concentrations greater than 35 pCi/g in soil depths up to 1.5 feet. Approximately 50 percent of the former production area soils contain uranium contamination exceeding 35 pCi/g. U-total concentrations greater than 35 pCi/g below 1.5 feet are primarily restricted to certain production and maintenance facilities. Concentrations of U-total in FEMP soils outside the production area and the waste storage area are generally less than 35 pCi/g. Exceptions include suspect areas such as the Fire Training Area, the Sewage Treatment plant area, and the rubble mound west of the K-65 silos. In addition, organic contamination occurs near facilities where chemicals were used for process development or in conjunction with machining and maintenance operations.

This project will provide for the excavation and treatment of contaminated soils to a level compliant with the US EPA-approved RAOs. Any delay in this project will result in further contamination of FEMP and surrounding soils due to airborne deposition, and further contamination of the Great Miami Aquifer caused by the transport of contaminants by rainfall infiltration.

1.5 Leading Remedial Alternatives

Typically during the CERCLA process, a Remedial Investigation/Feasibility Study (RI/FS) is prepared prior to initiating development of a CDR. After completion of the RI/FS, the DOE will submit a Proposed Draft ROD to the US EPA for approval. In order to facilitate long-range planning and budgeting, this CDR is being developed prior to completion of the RI/FS and issue of the CERCLA ROD. The Leading Remedial Alternative will be one of the alternatives discussed within the FS.

Table 1-2 presents the soil remedial alternatives identified in the final *Initial Screening of Alternatives for Operable Unit 5* (DOE 1992a).

Table 1-2 - Soil Remedial Alternatives (DOE 1992a)

Alternative	Description
1	No Action
2	Institutional Actions, Excavation, Intermediate Storage
3	Institutional Actions, Excavation, Disposal (Option 1: On-Site, Option 2: Off-Site)
4	Institutional Actions, Excavation of Sediments, Multilayer Capping
5	Institutional Actions, Excavation, Soil Washing, Intermediate Storage of Residuals
6	Institutional Actions, Excavation, Soil Washing, Disposal of Residuals
7	Institutional Actions, Excavation, Batch Vitrification, Backfilling of Vitrified Residuals
8	Institutional Actions, Excavation, Batch Vitrification, Disposal (Option 1: On-Site, Option 2: Off-Site)
9	Institutional Actions, Pozzolanic-Based/Cement-Based Stabilization/Solidification

This CDR is based on the assumption that the approved FS and Draft ROD will provide for the leading remedial alternative of Institutional Actions, Excavation, Soil Washing, Disposal of Residuals. Alternatives 1, 2, 3, and 4 were also considered and retained for a detailed evaluation. Alternatives 5, 7, 8 and 9 were rejected during the initial screening process for the following reasons:

1) Alternative 5 was rejected because of the uncertainties in the amount of time required to achieve ultimate cleanup and the fact that the short-term protection of human health and the environment during implementation will not be fully achieved due to the time and exposure risks associated with intermediate storage.

2) Alternative 7 was rejected because it would not achieve long-term effectiveness due to the risks associated with the contaminants remaining in the vitrified mass.

3) Alternative 8 was rejected due to its high costs and the uncertainty over the availability of disposal facilities.

4) Alternative 9 was rejected due to its questionable long-term effectiveness.

SECTION 2

PROJECT STRATEGY AND SCHEDULE

This section discusses the project Work Breakdown Structure (WBS) and how it is integrated into the overall site WBS, the proposed design and construction management system, the project design, procurement and construction strategies, project functional requirements, project milestone activities, and project schedules.

2.1 Project WBS

Figure 2-1 provides a WBS for the Soil Remediation project. This figure demonstrates how the project will be organized and managed at facility and integration levels. The facility level includes the design activities, and the project integration level includes construction and construction support activities.

Figure 2-2 provides a Responsibility Assignment Matrix that identifies the project participants (as defined at the time this CDR was prepared) and the work activities that each will perform. The work activities are tied to the project WBS. The participants include:

1) DOE
2) FERMCO
3) PARSONS
4) Construction Subcontractor

A summary of the roles and responsibilities that will be assigned to each participant in the matrix is described below:

<u>DOE</u>

The DOE is the owner of the FEMP, and is responsible for the oversight of all site activities. The DOE will provide project management and direct all aspects of the project including specific approval of assignments to the various participants and approval of all work performed.

BEING DEVELOPED

Figure 2-1 - Soil Remediation Project Work Breakdown Structure

BEING DEVELOPED

Figure 2-2 - Soil Remediation Project Responsibility Assignment Matrix

FERMCO

FERMCO is contracted to the DOE to manage the site. FERMCO will provide project management for the design work that will be performed by PARSONS and the construction that will be performed by a construction subcontractor. FERMCO will procure any special equipment. FERMCO has the primary responsibility for providing the following Title III engineering services during construction:

1) Construction contract activities and administration
2) Project coordination with existing FEMP operations and other construction projects
3) Interface with the DOE and Federal and State regulatory agencies
4) Pre-award construction meetings
5) Development of cost estimates for change requests
6) Construction inspection and quality control
7) Field quality assurance
8) Development of "red-line" drawings for as-builts
9) Archived storage of records after project closeout
10) Facility warranties and guarantees
11) Disposition of design clarification requests
12) Disposition of field change requests
13) Disposition of vendor data and equipment observations at vendor shops
14) Equipment and systems operational testing, checkout, inspection, and acceptance
15) Preparation of various plans in support of the project

Project support plans include, but are not limited to, Safety and Risk Assessment documents, Health and Safety plans, operating procedures, and training and lesson plans. FERMCO will provide project support services including subcontractor personnel training, health and safety monitoring, radiation monitoring, and transportation and disposal of construction debris.

PARSONS

PARSONS is the Architect-Engineering firm contracted to FERMCO to provide remedial design support for the FEMP site remediation. PARSONS will perform Title I and II engineering for this project. Design deliverables will include drawings, construction specifications, equipment data sheets, and a cost estimate. PARSONS will provide Title III engineering support to FERMCO including:

1) Review of vendor data submittals

2) Disposition of design change requests

3) Development of as-built drawings

4) Disposition of field change requests as requested by FERMCO

5) Disposition of vendor data and equipment observations at vendor shops as requested by FERMCO

6) Development and final disposition of punch lists during the final inspection and acceptance stage as requested by FERMCO

Construction Subcontractor

A construction subcontractor will be selected via the DOE contract procurement process to construct the soil remediation system and facilities. The construction subcontractor will provide all labor, materials, equipment, and transportation necessary to construct the soil remediation system and facilities.

2.2 Project Strategy

The following subsections describe the proposed strategies for design, procurement, and construction. These strategies correlate with the Summary Project Schedule presented in Subsection 2.5 and the spendout costs presented in Section 3 of this CDR.

2.2.1 Design Strategy

A Design Criteria Report (DCR) will be prepared based on the findings and conclusions of this CDR and appropriate RI/FS documentation. The DCR will provide the technical basis for the design of the soil remediation project. The DCR will be completed in November 1994, prior to initiating the Title I/II design. Title I/II design work for the soil remediation project will comply with DOE Order 6430.1A, General Design Criteria. Title I/II design shall commence in November 1994 and take approximately 25 months to complete. Title I/II design will be performed in support of the planned sequence of procurement and construction so that a lump sum procurement package can be let to prospective bidders by November 1996.

2.2.2 Procurement Strategy

Procurement of the soil remediation project shall commence in November 1996. A lump sum construction contract will be awarded in March 1997. Long lead-time equipment design packages will be prepared as early as possible to adhere to the project schedule. Vendor data on long-lead items will be required to support the design effort.

2.2.3 Construction Strategy

Construction of the soil remediation project, from contract award to completion of operational testing, shall take approximately 12 months. Section 2.5 outlines the sequence of the soil remediation project construction phase.

The soil remediation project facilities are assumed to be pre-engineered buildings. It is also assumed that adequate power and utilities are available at or near the project site. Service connections of site utilities are required. A new electrical substation is required to support the soil remediation project systems.

2.2.4 Operating Strategy

The soil remediation project's soil washing system will operate 24-hours per day, 365 days per year. The operating life of the project is assumed to be 21 years, 2 months. In reality, the soil remediation project will operate until the soil RAOs specified under the US EPA-issued ROD are met.

Staffing requirements are based on five 8-hour shifts per man per week, and include actual workers required to cover weekends, holidays, vacations, and sick leave. Full time staffing requirements are being determined and will be included in subsequent submittals of this CDR.

2.2.5 Closure/Post Closure Strategy

This section will discuss the strategy for closing the project after RAOs are met, decontamination/decommissioning plans, and any long-term monitoring requirements. It is currently being developed and will be included in subsequent submittals of this CDR.

2.3 Functional Requirements

2.3.1 Introduction

This subsection provides the basis for the development of the soil remediation project and defines the functional objectives for each element of the soil remediation project. This subsection also includes the assumptions used to develop the conceptual design, the constraints and limitations placed on the design, and the regulatory and design requirements. Figure 2-3 shows the functional elements of the soil remediation project graphically. The remainder of this subsection is organized by these functional elements.

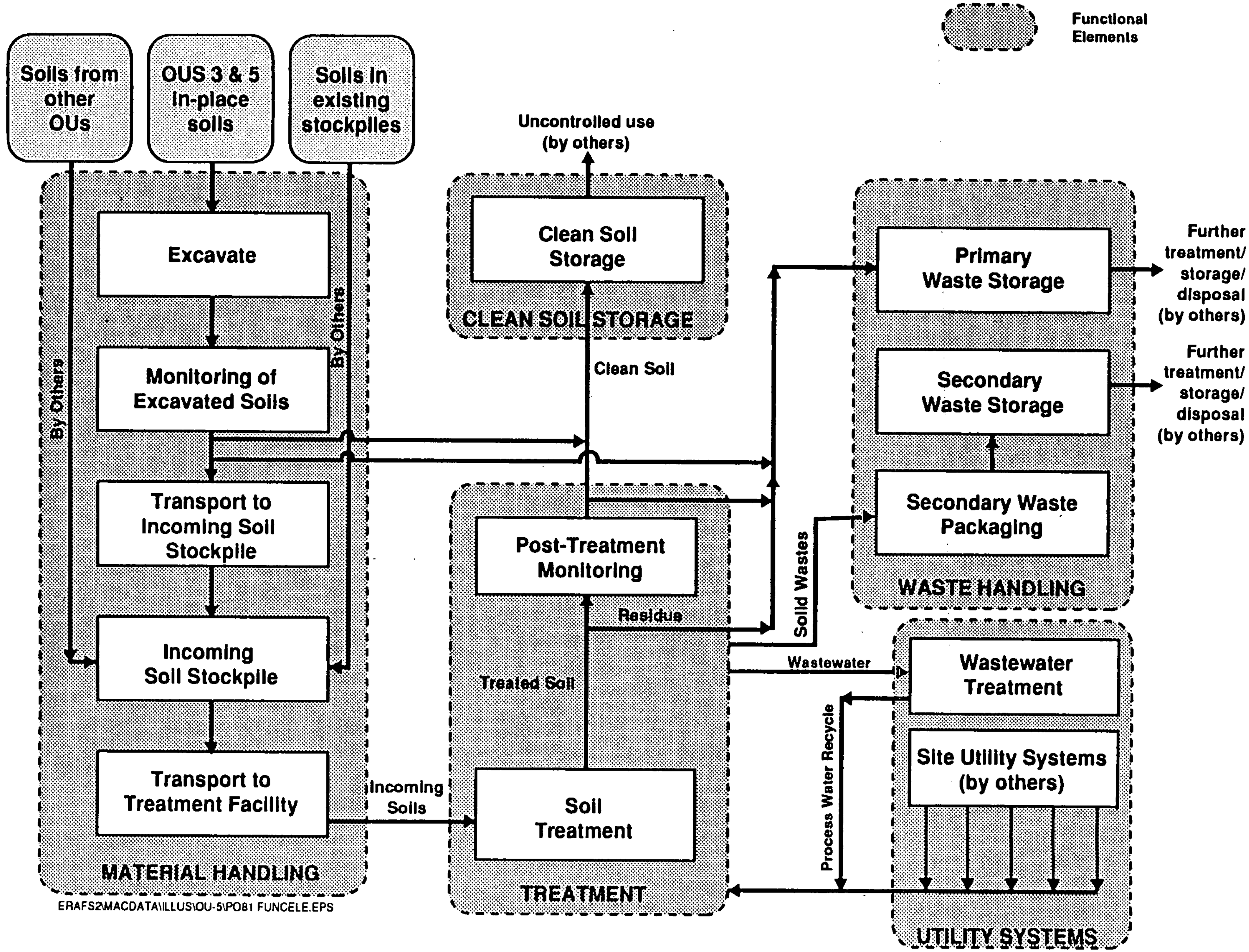

Figure 2-3 - Soil Remediation Project Functional Elements

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The following terms are used in this section:

1) "Incoming Soil" is destined for treatment in the treatment facility. Generally, it will be contaminated with greater than 35 pCi/g of depleted uranium. It may contain other contaminants as well.

2) "Treated Soil" has been through the uranium reduction treatment process. It may still not be satisfactory for uncontrolled use due to concentration levels of other contaminants.

3) "Clean Soil" is acceptable for (uncontrolled) re-use on the site because it does not contain any contaminant (including uranium) concentrations above the clean-up levels.

4) "Residue" is the soil fraction into which the uranium contaminants are concentrated during treatment. (It may also contain other contaminants.)

5) "Primary Waste" includes soil and excavated material that have passed through the treatment system but cannot be released for re-use on the site due to contaminants (other than uranium) that are still above their associated clean-up levels. This category also includes the uranium-contaminated soil residue (see above) and any soil or debris that cannot be processed (because of its size or other reasons).

6) "Secondary Wastes" are the non-soil wastes generated by the treatment process (e.g., filtrate, filter media, sludges, wastewater, etc.).

2.3.2 Functional Objectives

2.3.2.1 General Objectives

1) FEMP soils (either in-place or in stockpiles) which have contaminant concentrations equal to or exceeding the assumed clean-up levels will be removed and treated to ensure that their uranium concentrations are below 35 pCi/g.

2) All facilities will be designed and constructed to allow for efficient future decontamination and decommissioning.

3) The systems shall maximize the amount of soil available for uncontrolled use.

2.3.2.2 Material Handling

1) In-place OU-3 and OU-5 soils will be excavated, temporarily stored, and transported to the treatment facility.

2) The soil excavation plan shall be based on concentrations of total uranium (U-total) exceeding 35 pCi/g. Soil will be monitored at excavation to determine whether it requires treatment for uranium removal. Excavated soils with U-total levels below 35 pCi/g will be set aside for further testing to determine if they can be used as uncontrolled backfill or must be handled as primary waste.

3) Sufficient quantities of incoming soil requiring remediation will be stockpiled to allow continuous operation of the treatment system. Incoming soil may be stockpiled at the soil washing facility and/or at the CSF.

4) Stockpiles of incoming soil will be segregated to the extent possible based on types of contamination. Incoming soils that contain both hazardous waste contaminants and free liquids must be stored in an area with secondary containment. Soil containing significant contamination may have other types of storage requirements.

5) All material handling methods and equipment shall be designed with Human Factors/Ergonomics engineering as a key element of the design.

2.3.2.3 Treatment

1) There shall be a single, stationary treatment facility. Soil washing will be the treatment technology. The treatment systems will physically separate organic material such as roots and branches from the soil. The treatment system will reduce the uranium concentration to 35 pCi/g or less without significantly degrading the physiological characteristics of the soil.

2) Soil washing may not remove all contaminants to below their clean-up levels. Treated soil shall be monitored to determine if it may be used as uncontrolled backfill (clean soil) or must be handled as primary waste (residue).

2.3.2.4 Clean Soil Storage

1) Clean soil will be stockpiled until it is transported for uncontrolled use.

2.3.2.5 Waste Handling

1) Short-term storage of primary and secondary wastes will be required.

2) Primary and secondary wastes will be packaged (as necessary) and transported to final disposal facilities.

2.3.2.6 Utility Systems

1) Utility support system interfaces (including pipelines for supply of process water and discharge of contaminated wastewater) will be provided by this project from existing or proposed site utility systems.

2.3.3 Regulatory and Design Requirements

CERCLA projects must comply with all Applicable or Relevant and Appropriate Requirements (ARARs) consisting of Federal and State environmental regulations. Additionally, all FEMP projects must be conducted in accordance with specific DOE orders for environmental, safety, and health and facility design. The following subsections address these requirements.

2.3.3.1 Applicable or Relevant and Appropriate Requirements

40 CFR 300.430(f) requires that the selected remedial alternative satisfies all non-waived ARARs. The soil remediation system must comply with those ARARs identified for OU-5 and approved by the US EPA. To date, the US EPA has not approved a final list of ARARs for OU-5. The ARARs identified by this document (located in Volume II, Attachment B) are based on the preliminary list of ARARs and the current understanding of the scope of this project. For each ARAR identified, the regulatory citation, a summary of the requirement, and the implementation strategy are provided. The implementation strategy will be expanded in the Remedial Action Work Plan to explain how each identified ARAR will be met or to reiterate the grounds for invoking a waiver of the ARAR under 40 CFR 300.430(f)(1)(ii)(C). The implementation strategies and associated conceptual design criteria may need to be revised in response to the US EPA's final approved list of ARARs.

Non-regulatory guidance documents and proposed regulations termed "To Be Considered" (TBC) will also be met to the extent possible. Pertinent TBCs are included in the ARAR list in Volume II, Attachment B. The incorporation of TBCs will be determined by the DOE/FERMCO.

2.3.3.2 DOE Orders

The soil remediation system must be designed to ensure compliance with DOE orders and policies regarding nuclear safety, radiation safety, industrial safety, fire protection, and environmental protection. In accordance with DOE Order 6430.1A Section 1300-1.3, the facilities will be designed to protect the public and facility personnel from hazards associated with the use of radioactive and other hazardous material as a result of normal operations, anticipated operational occurrences, and design basis accident conditions (including the effects of natural phenomena pertinent to the FEMP). Fire protection will conform to FEMP and National Fire Protection Association (NFPA) standards.

The facilities must be designed so that annual radiation exposures to occupational workers are kept less than 1 rem, the FEMP administrative level for a whole body dose. DOE Order 6430.1A, "General Design Criteria," states that facility design must limit exposure to one-fifth of the limits in DOE Order 5480.11, "Radiation Protection for Occupational Workers." The treatment facility and incoming soil storage area shall meet radioactive solid and liquid waste facility requirements. The facilities will also be designed to minimize exposure of personnel and the general public to radioactive materials in accordance with the guidance provided in the *Health Physics Manual of Good Practices for Reducing Radiation Exposure to levels that are As Low As Reasonably Achievable (ALARA)* (PNL 1988), the DOE-HQ Radiological Controls Requirements Manual (RM-0009), and DOE Order 6430.1A, "General Design Criteria."

The soil remediation system will be designed in accordance with the following DOE orders at a minimum:

1) DOE Order 5400.1, "General Environmental Protection Program."
2) DOE Order 5400.5, "Radiation Protection of the Public and the Environment."
3) DOE Order 5480.11, "Radiation Protection for Occupational Workers."
4) DOE Order 5820.2A, "Radioactive Waste Management."
5) DOE Order 6430.1A, "General Design Criteria."

2.3.3.3 Other Design Requirements

The following other regulations, DOE orders, and industrial codes and standards will be reviewed and used (where appropriate) during the design of the soil remediation facility:

1) Code of Federal Regulations, 10 CFR 435, "Energy Conservation Voluntary Performance Standards for New Buildings."

2) American Concrete Institute (ACI), 1989, ACI-318-89, "Building Code Requirements for Reinforced Concrete."

3) American Institute of Steel Construction, Inc., "Manual of Steel Construction," 9th Edition.

4) American Society of Civil Engineers, 1990, ASCE 7-88, "Minimum Design Loads for Buildings and Other Structures."

5) United States Department of Energy, DOE Order 4700.1, "Project Management System."

6) United States Department of Energy, DOE Order 5700.6C, "Quality Assurance."

7) United States Department of Energy/Technical Information Coordinator 1986, DOE/TIC 11603, Rev. 1, "Nonreactor Nuclear Facilities: Standards and Criteria Guide."

8) National Fire Protection Association, NFPA 70, "National Electrical Code."

9) National Fire Protection Association, NFPA 101, "Life Safety Code."

10) Ohio Basic Building Code (OBBC), 1992, OBBC-1992.

11) RM-0013, Rev. 0, "Fire Protection Requirements Manual."

12) RM-FMPC-0001, 1990, "Feed Materials Production Center (FMPC) General Design Criteria Manual."

13) Site Standard Operating Procedure, SSOP-0044, "Management of Soil, Debris, and Waste from a Project (to be revised per RA-17 Work Plan)."

14) Uniform Building Code (UBC), UBC-91.

15) University of California Research Laboratory (UCRL), UCRL-15910, "Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards, 1990."

16) American Society of Mechanical Engineers (ASME), 1992, ASME-92, "Boiler and Pressure Vessel Code, Section VIII."

17) American Society of Mechanical Engineers, 1990, ASME-B31.3-90, "ASME Chemical Plant and Petroleum Refinery Piping."

18) TM-FMPC-2089, "The On-Site Transportation of Radioactive and Nonradioactive Hazardous Materials."

2.3.4 Assumptions

2.3.4.1 General Assumptions

1) The SRSS (contained in Volume II) contains a recommended soil remediation strategy and schedule which will be the basis for this CDR.

2) The soil remediation system will operate for 21 years, 2 months.

3) The SCQS provides the assumed action levels used to determine which soils will be excavated.

2.3.4.2 Material Handling

1) FEMP soils are composed of gravels, silts, and clays in various combinations. An average swell factor of approximately 30 percent is assumed between the in-place volumes and the loose (or excavated) volumes of soils.

2) Soils will not be excavated deeper than the glacial till (ranging from 3 to 30 feet).

3) No additional containment will be required for the areas being excavated.

4) Soil excavated by OUs 1, 2, and 4 will be transported to defined incoming soil stockpiles by the generator. These soils will meet the soil treatment facility acceptance criteria.

5) OUs 3 and 5 soils excavated by CRU-5, or already stored in soil stockpiles, shall be transported to the incoming soil stockpiles by CRU-5.

6) A maximum of 3,500 tons of soil will be available at an enclosed incoming soil stockpile located adjacent to the treatment facility. Other contaminated soil stockpiles will also be available to ensure continuous treatment system operation.

7) The excavation and transportation systems shall operate 5 days/week, one shift/day. Redundant equipment shall be provided to ensure 100 percent system availability.

2.3.4.3 Treatment

1) The treatment goal is assumed to be ≤ 35 pCi/g U-total in soil, pending approval by the US EPA and Ohio Environmental Protection Agency (Ohio EPA). Treated soil that does not meet this treatment goal may be reprocessed or handled as primary waste.

2) Approximately 1.4 million cubic yards (approximately 2.4 million tons) of contaminated soil will be treated.

3) The system will be able to handle various combinations of silt, gravel, and clay.

4) Commercially available equipment will be used to the extent practical.

5) The system shall incorporate the use of existing FEMP equipment to the extent possible.

6) The clean soil is assumed to have a volume that is only 70 percent of the volume of the incoming soils.

7) The treatment system shall operate 7 days/week, three shifts/day, with an 85 percent or better on-stream factor and a 75 percent processing efficiency. The total annual treatment capacity is assumed to be 109,500 tons (based on a nominal treatment capacity of 12.5 tons/hour [rated capacity 20 tons/hour by 0.85 on-stream factor by 0.75 processing efficiency = 12.5 tons/hour]).

2.3.4.4 Clean Soil Storage

1) Clean soil shall be stockpiled outdoors, adjacent to the treatment facility before being transported for uncontrolled use.

2.3.4.5 Waste Handling

1) Up to 750 tons of primary waste storage shall be provided before the waste is transported to final disposal on site. Transportation is included in the scope of this project, but final disposal will be by others.

2) Wastewater shall be treated and recycled for use in the soil washing facility to the extent possible. A small portion will be sent to the AWWT system (after pretreatment to remove solids) for further treatment.

3) It is assumed that primary and secondary waste will be disposed of on site. The waste acceptance criteria for on-site disposal are assumed to be the same as was defined in the CDR, "Functional Requirements for the Engineered Disposal Facility," dated May 21, 1991.

2.3.4.6 Utility Systems

1) Sufficient utilities, including process water from the AWWT system, will be available from existing or proposed systems at the FEMP site for the entire life of this project. This project is assumed to include connections to existing FEMP fire, electrical power, stormwater, potable water, sanitary sewer, alarm, process water, plant air, and telephone utilities.

2.3.5 Constraints and Limitations

2.3.5.1 General Constraints and Limitations

1) All applicable regulatory requirements, site standards, and DOE requirements shall be met (see Item 2 in Subsection 2.3.5.1 and Item 1 in Subsection 2.3.5.2 for particular concerns).

2) Runon and runoff control and stormwater management are required at all facilities, including all soil stockpiles.

3) The remediation schedules of the other OUs will affect both excavation and reclamation (see SRSS, Volume II).

4) Minimizing cross-contamination of clean areas and control of air emissions are required in all phases of the operation.

2.3.5.2 Material Handling

1) Special worker protection may be required when handling soils that are contaminated with other (than U-total) contaminants and hazardous substances. A Preliminary Hazards Analysis will be prepared as part of the Safety Assessment to determine the need for worker protection.

2) Many excavation decisions will be made in the field, based on contamination levels unearthed in order to avoid removing clean soils.

3) Excavation will not occur during extreme weather conditions such as heavy rains, tornados, frozen ground, etc.

4) The Incoming Soil Storage areas must meet Radioactive Solid Waste Facilities criteria.

2.3.5.3 Treatment

1) The treatment facility shall be sited in an uncontaminated area to minimize the cost of contaminated soil handling and not interfere with other FEMP remedial activities.

2) The treatment facility shall meet Radioactive Liquid Waste Facility criteria.

3) Boulders ($\geq$ 1 foot diameter) and other debris cannot be treated in the system. They will be segregated and disposed of as debris in other facilities (by others).

2.3.5.4 Clean Soil Storage

1) The Clean Soil Storage area shall be sited in an uncontaminated area. It will only require erosion control.

2.3.5.5 Waste Handling

1) Waste packaging/storage and transport must be coordinated with the receiving facilities and meet their acceptance criteria.

2) The waste handling areas shall meet Radioactive Solid Waste Facilities criteria.

2.4 Project Milestones

Table 2-1 presents the project milestones representing critical events which must occur in order for the soil remediation project to achieve its objectives. Project milestones are based on schedule data contained in the RI/FS and Remedial Action Schedule Report, CERCLA/RCRA Unit 5, Environmental Media, dated September 27, 1993 (FERMCO 1993).

2.5 Project Schedule

Figure 2-4 presents a Summary Project Schedule. It is the basis for development of the CDR cost estimate.

Table 2-1 - Soil Remediation Project Milestones

Project Activity	Milestone Date
Start CDR	September 21, 1992(A)
Start DCR	January 6, 1994
Issue Final CDR	March 3, 1994
Issue Final DCR	November 2, 1994
Start Title I/II Design	November 3, 1994
Start Remedial Design (RD) Work Plan	March 13, 1995
Start Remedial Action (RA) Work Plan	April 10, 1995
Submit RA Work Plan to US EPA	October 3, 1995
US EPA Approve RA Work Plan	November 2, 1995
DOE Implement RA Work Plan	November 2, 1995
Submit RD Work Plan to US EPA	January 4, 1996
US EPA Approve RD Work Plan	March 8, 1996
DOE Implement RD Work Plan	March 8, 1996
Issue CFC Design	November 25, 1996
Award Contract	March 20, 1997
Subcontractor Start Mobilization	March 21, 1997
Start Operations/Remediation	June 29, 1998
Remediation Complete	August 28, 2019

(A) = Actual Date

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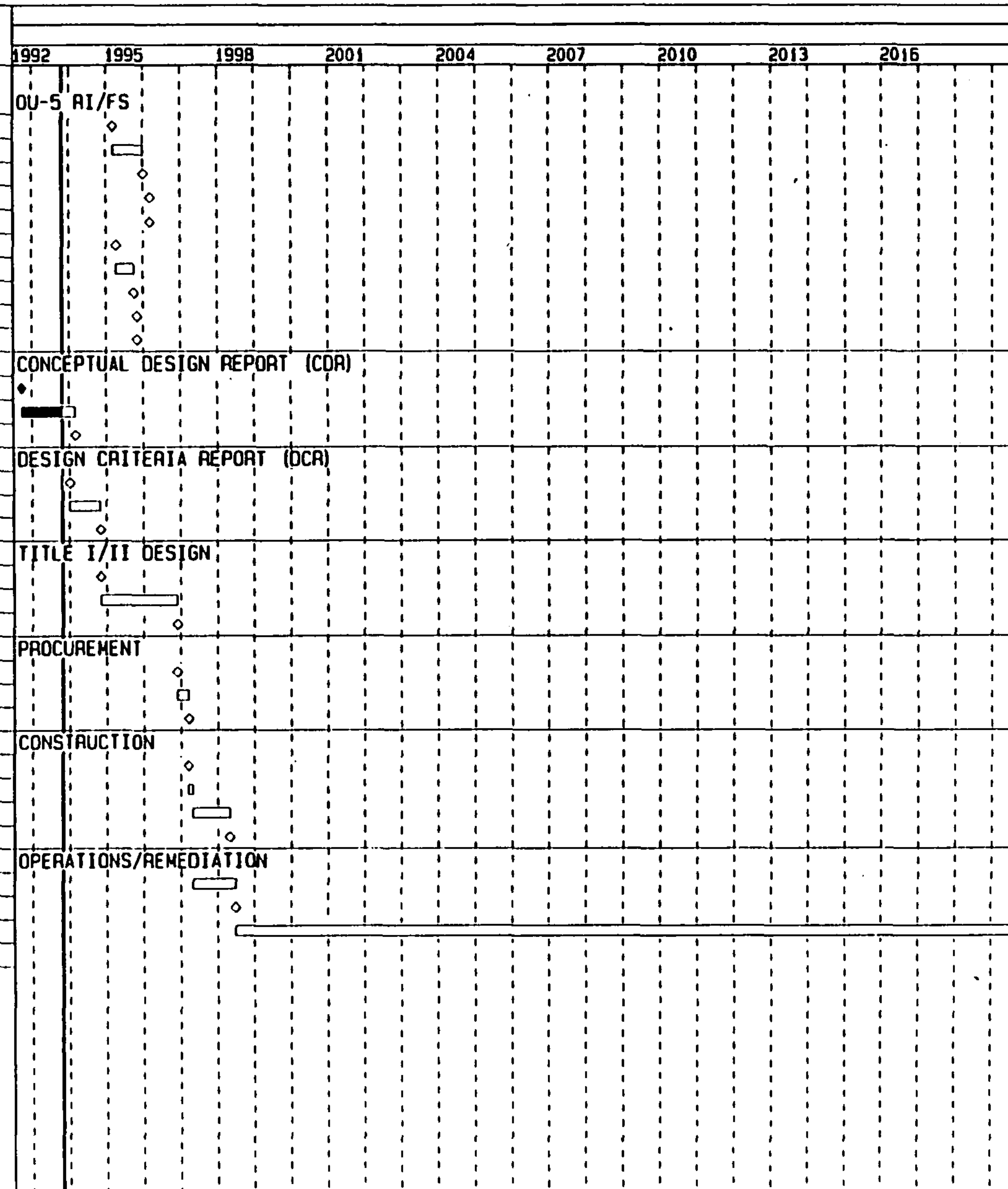
ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH
RD WORK PLAN - START	13MAR95	
PREPARE RD WORK PLAN	13MAR95	4JAN96
ISSUE RD WORK PLAN TO US EPA		4JAN96
US EPA APPROVE RD WORK PLAN		8MAR96
IMPLEMENT APPROVED RD WORK PLAN	8MAR96	
RA WORK PLAN - START	10APR95	
PREPARE RA WORK PLAN	10APR95	3OCT95
ISSUE RA WORK PLAN TO US EPA		3OCT95
US EPA APPROVE RA WORK PLAN		2NOV95
IMPLEMENT APPROVED RA WORK PLAN	2NOV95	
CDR PREPARATION - START	21SEP92A	
PREPARE CDR	21SEP92A	3MAR94
ISSUE FINAL CDR TO FERMCO		3MAR94
DCR PREPARATION - START	6JAN94	
PREPARE DCR	6JAN94	2NOV94
ISSUE FINAL DCR TO FERMCO		2NOV94
TITLE I/II DESIGN - START	3NOV94	
PREPARE TITLE I/II	3NOV94	25NOV96
ISSUE CFC DESIGN TO FERMCO		25NOV96
PROCUREMENT - START	26NOV96	
ADVERTISE	26NOV96	20MAR97
AWARD CONTRACT		20MAR97
CONSTRUCTION - START	21MAR97	
SUBCONTRACTOR MOBILIZATION	21MAR97	1MAY97
CONSTRUCTION	2MAY97	28APR98
CONSTRUCTION - COMPLETE		28APR98
OPERATIONAL TESTING	29APR97	26JUN98
OPERATIONS/REMEDIATION - START	29JUN98	
OPERATIONS/REMEDIATION	29JUN98	28AUG19
REMEDIATION - COMPLETE		28AUG19



Plot Date 8NOV93
Data Date 25OCT93
Project Start 1SEP92
Project Finish 28AUG19

(c) Primavera Systems, Inc.

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

Sheet 1 of 1

CRU-5/PO-81
OU-5 SOIL REMEDIATION PROJECT
SUMMARY PROJECT SCHEDULE

Date	Revision	Checked	Approved

Figure 2-4 - Summary Project Schedule

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SECTION 3

PROJECT COST AND FUNDING STRATEGY

This section presents the costs for project design, construction, operation, and closure/post-closure.

3.1 Summary Estimate

The summary estimate will present the total estimated cost for the project, including:

1) Engineering studies
2) Design
3) Construction
4) Operation
5) Closure/Post-Closure
6) Contingency
7) Escalation

The level of detail (accuracy) for the cost estimate will be +30 to -50 percent.

3.2 Funding Strategy

This subsection will be completed by FERMCO.

3.3 Engineering Design Cost

This subsection will include a discussion of the engineering efforts required for implementing the project. Engineering design costs include preparation of the following deliverables:

1) CDR
2) Engineering studies (i.e., SCQS, SRSS, TER)
3) DCR
4) Title I/II design

3.4 Reconciliation

This subsection will address soil remediation-related projects which have previously been performed and need to be redone to address new scope or conditions. This subsection may also include an explanation of any unusual project costs.

SECTION 4

RELATED PROJECT TASKS, SCHEDULES, AND COSTS

This section discusses any additional engineering studies required for the soil remediation project and provides estimated costs by fiscal years for these efforts.

4.1 Engineering Development Studies and Related Tasks with Schedule and Costs

Five preliminary engineering studies are being prepared in support of the CDR. The following subsections describe the scope, schedule, and cost of each preliminary engineering study:

4.1.1 Soil Characterization and Quantification Study

While the primary contaminant of interest is uranium, FEMP soils have been found to contain numerous other contaminants, including other radionuclides, heavy metals, and organics. Different contaminated soils may require different treatment technologies and/or treatment system operating conditions. In order to optimize design of the soil treatment system, the volumes of soils containing different contaminants must be known. OU-5 Remedial Investigation/Feasibility Study soil sampling program data collected from the FEMP areas was analyzed. In addition, soil sampling data from other FEMP activities such as removal actions, maintenance activities, Removal Site Evaluations, and general environmental monitoring made available by FERMCO was analyzed. No new soil sampling/data collection was performed for this study. Geotechnical soil data was not included in the soil study. The Environmental Resource Management Analysis/Geologic Information System (ERMA/GIS) was used to generate plan maps showing the estimated locations and magnitude of contamination in surface soils. Additionally, limited elevational sections were developed for areas of deeper contamination.

The Enhanced Cost Study for Soil Remediation at the FEMP, dated September 30, 1992, developed an estimate of the total quantity of FEMP soils requiring remediation. The estimated soil quantities containing differing types of contaminants were refined using the ERMA/GIS-generated maps. Estimates of the contaminated soil volumes for each OU were developed. These OU-specific volumes were used during the SRSS and as part of the technical basis for this CDR.

The SCQS was started on March 8, 1993, and is scheduled to be completed on January 21, 1994. The total cost of the SCQS will be provided in subsequent submittals of this CDR.

4.1.2 Soil Remediation Schedule Study

Current OU remediation schedules and plans were analyzed to determine their impact on current CRU-5 soil remediation schedules and plans. The FERMCO Integrated Site Master Schedule, dated July 19, 1993, was used as the basis for OU remediation schedules. Representatives of each CRU provided contaminated soil volume estimates for each OU. The results of the SCQS, the FERMCO CRUs' contaminated soil volume estimates, and current OU remediation schedules were used to prepare an integrated soil remediation strategy. A recommended soil remediation schedule and plan, consistent with the OUs' remediation plans, was developed to better define the material (soil) flow requirements. The recommended soil remediation strategy was used as part of the technical basis for this CDR.

The SRSS was started on August 2, 1993, and is scheduled to be completed on January 21, 1994. The total cost of the SRSS will be provided in subsequent submittals of this CDR.

4.1.3 Technical Evaluation

DOE Order 4700.1 requires that project scoping studies and technical alternative evaluations be performed prior to entering the design phase of a project. The Technical Evaluation Report (TER) summarized why the *Treatability Study Work Plan For Operable Unit 5 Soil Washing* (DOE 1993a) identified soil washing as a viable treatment technology for soil remediation. In addition, the preliminary results of the three soil treatability studies (Minimum Additive Waste Stabilization [MAWS], ID, and OU-5) were integrated into an optimized soil washing process for full-scale operation which will be part of the technical basis for this CDR.

The TER also included an evaluation of whether the soil washing system should be a central facility, one or more portable systems, or a combination of both. The TER also evaluated project siting alternatives based on traffic staging, material handling, and site utility considerations, among others. It was assumed that remediated soils will be reused on site. A brief soil remediation literature review has shown that in soils with a high clay content (e.g., FEMP soils), the "clean" soil fraction is primarily silt because most of the contaminants reside with the clay portion. The resulting "clean" soil is so silty that its use is limited. Therefore, the TER examined uses for the "clean" soil fraction after treatment.

The TER was based on preliminary data generated by the following soil treatability studies:

1) OU-5 Soil Washing Treatability Study being performed by FERMCO CRU-5 and International Technology Corporation

2) DOE-FEMP ID Program Soil Treatability Study being performed by Oak Ridge National Laboratory

3) OU-1 MAWS Program Soil Washing Treatability Study being performed by Lockheed Environmental Systems and Technology

The TER was started on March 8, 1993, and is scheduled to be completed on January 21, 1994. The total cost of the TER will be included in subsequent submittals of this CDR.

4.1.4 Safety Assessment

A Safety Assessment (SA) will be prepared in accordance with the new FERMCO Safety Analysis Department procedures. The SA will be a brief, concise document that will identify the nature of any hazards associated with the project. The conclusions of the SA will be used to determine the scope of any additional safety analysis work, if required. As a result of the SA, one of the following three conditions will be met:

1) The project has only standard industrial hazards and no additional safety analysis will be required.

2) Non-standard hazards will be present and the quantity of radioactive material will exceed the limits in DOE-STD-1027-92 and a DOE approved Safety Analysis Report (SAR) will be required.

3) Non-standard hazards will be present and the limits are not exceeded thereby requiring a FERMCO approved Auditable Safety Record instead of a SAR.

The SA was started on July 6, 1993, and is scheduled to be completed on February 28, 1994. The total cost of the SA will be included in subsequent submittals of this CDR.

4.1.5 Material Handling Plan

A Material Handling Plan will be prepared as part of this CDR. The plan will be based upon the results of the SCQS, the SRSS, the TER, and the following considerations:

1) Feed requirements of the soil washing system
2) Stockpile capacities (contaminated and clean soil stockpiles)
3) Size and shape of the areas to be excavated
4) OU remediation schedules (i.e., the OU-3 D&D schedule)
5) Production rates of the excavation equipment to be employed
6) Decontamination requirements of mobile equipment
7) Soil types excavated
8) Stormwater runoff control in active excavations

The plan will provide effective planning and scheduling of the excavation of each OU, and optimize the size and make-up of the material handling equipment fleet. The plan will provide the following documents which will be included in this CDR:

1) Material flow diagrams

2) Typical excavation cross sections illustrating soil excavation, soil placement, and stormwater run-off control measures

3) A CDR section detailing the requirements of soil excavation, soil placement, and containerizing and handling of soil residues

The Material Handling Plan was started on November 1, 1993, and is scheduled to be completed on January 21, 1994. The cost of the material handling plan is included in the total cost of the CDR.

SECTION 5

QUALITY ASSURANCE

A Project Quality Assurance Program (PQAP) Plan and its measures will be implemented during design, procurement, and construction of the soil remediation project.

5.1 Project Quality Assurance Program Plan

The PQAP Plan establishes the quality requirements for Title I, II, and III work performed, and shall be in conformance with the requirements of DOE Order 5700.6C, Quality Assurance. A quality assurance standard which meets the majority of the requirements of the order for the development and implementation of quality assurance programs is American National Standards Institute/ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities.

5.2 Quality Classifications

The soil remediation project will use a "graded" Quality Level (QL) for all design, procurement, and construction activities. These levels are related to the importance of safety, environmental impact, laws and regulations, DOE orders, project mission/goals, program schedules and commitments, and potential cost impact of failures. The determination of QLs is established in a Risk Assessment and Management System documented by the FEMP in site policies and procedures and will be implemented by subcontractors as directed by the FEMP.

5.3 Plan Implementation

Documented project procedures will be established to ensure that activities are conducted in an organized, systematic, and consistent manner, that procedures are used, and that program orientation and training is conducted. Procedures shall be developed for activities affecting quality. These procedures provide mandatory requirements for accomplishing project work. The Project and Site Quality Assurance Organizations verify and assess, as applicable, that requirements are met by reviewing, conducting surveillances, auditing, inspecting, and documenting whether items, processes, or services meet specified requirements. Quality Assurance Procedures will be developed to provide the requirements for activities of the Quality Assurance Organizations.

5.4 Exceptions

No exceptions to governing codes and standards are currently expected to be required on this project. The DCR phase of project development will also consider this issue.

Consistent with DOE-Fernald Field Office Letter DOE-0895-93, dated February 23, 1993, further consideration of applicable exceptions will be addressed as the CDR proceeds from 50 percent complete to 90 percent complete.

SECTION 6

SAFETY, ENVIRONMENT, AND ENERGY CONSIDERATIONS

This section identifies and discusses the hazards, safety standards, environmental protection systems, consequences to the environment, and energy requirements related to the design, construction, and operation of the soil remediation project.

6.1 Safety Assessment

This section will summarize the results of the SA being prepared, state the facility hazard classification, and identify whether or not a detailed safety Analysis Report will be required during Title I/II design. This section will be completed in subsequent submittals of this CDR.

6.2 Environmental Considerations

The soil remediation project will require National Environmental Policy Act documentation to assess whether the facility will cause any significant environmental impacts.

The soil remediation project will be located in a previously-undeveloped area of the FEMP site as shown in Figure 1-2. A review of FEMP historical records indicates this area was not previously used for process operations.

While the ACA does not specifically identify FEMP-wide soil remediation as a removal action, it does require that the DOE cleanup releases and threatened releases of hazardous substances from the FEMP. The soil remediation project will be designed, constructed, and operated in accordance with applicable Federal, State, and local environmental rules and regulations. ARARs have been identified and are included in Volume II, Appendix B.

The soil remediation project will process soil contaminated with both radiological and hazardous wastes. The soil remediation process will generate radiological and hazardous wastes in the form of the contaminated soil fraction remaining after treatment, the concentrated contaminant residue, and process wastewater. The radiological and hazardous wastes treated and generated by the soil remediation project will be managed in accordance with applicable Federal, State, and local rules and regulations.

The following subsection discusses some of the applicable Federal and State environmental rules and regulations regarding radiological and hazardous contaminants in soil.

6.2.1 Fedironmental Regulations for Contaminated Soil

6.2.1.1 Haztaminants

The proposed rule Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDRs) 40 CFR 268 et al) intends to treat soil with hazardous waste under the "contained/3); similar to the one that was finalized for hazardous debris (see 57 FR 37225 following paragraphs present a more detailed analysis of this development.

The codification of iciple applied to both media and non-media debris. The "contained-in" policyl in 40 CFR 268.45(c) and states the following:

> Hazardous ded using one of the specified extraction or destruction technologiesction and that does not exhibit a characteristic of hazardous wbpart C, part 261, of this chapter after treatment is not a hazardot be managed in a subtitle C facility. Hazardous debris contaaste that is treated by an immobilization technology specified in 'waste and must be managed in a subtitle C facility.

It is envisioned that till apply to contaminated soil.

This determination fdves a case-by-case examination by the US EPA, made upon request, that debris dus waste at significant levels, taking into consideration such factors as site hydrolare pathways, <u>but excluding management practices</u>. Material meeting the requiremsed without further treatment.

Currently, soil is ms waste even when the hazardous waste component or characteristic is remce "mixture rule" (40 CFR 261.3(c)(2))" and "derived from rule" (40 CFR 261(:However, proposed mixture and derived from rules may establish de minimisry concern) levels of hazardous waste. This would be consistent with the "omulgated with the debris LDR rule discussed above.

Hazardous waste cail by many different technologies; including incineration, chemical extraction, ictants. The effectiveness of these technologies is dependent upon the soil type.

Current characterizats a minimal amount of soil at the FEMP contains hazardous waste. Table 6-1 pre concern for contaminated soil. The constituents of concern were chosen from the *Characterization Report (DOE 1993)*. Constituents were chosen based upon their prevalence in the site soil and the toxicity of the particular constituent. The table also contains action levels for these constituents based on a recreational land use scenario. The action levels were taken from the preliminary remediation goals presented in the *Site-Wide Characterization Report* (DOE 1993).

6.2.1.2 Radiological Contaminants

The proposed rule for contaminated soil (40 CFR 268 et al) only vaguely addressed the remediation of soil containing radiological contaminants. Radiological contamination in media is better addressed in the proposed rule for 10 CFR 834 - *Radiation Protection of the Public and the Environment*; the codification of DOE Order 5400.5. Since this is a proposed rule, it should be considered as a TBC requirement. However, it is scheduled to be finalized in January 1994 per the DOE's most recent regulatory agenda. While, as a DOE order, the requirements were also TBCs, the proposed rule status means that it is very probable that these requirements will become future ARARs.

The proposed rule for 10 CFR 834, *Radiation Protection of the Public and the Environment* (58 FR 16268), recommends an authorized limit for depleted uranium in soil. Uranium is the predominant contaminant in soil at the FEMP. It has been proposed that the average soil concentrations over any 10 meter by 10 meter area should not exceed 35 pCi/g (that is, 35 picocuries of depleted uranium per gram of soil); and 100 pCi/g should not be exceeded over any 1 square meter area (58 FR 16276).

Forty-seven sites, remediated under the DOE Formerly Utilized Sites Remedial Action Program, were evaluated that utilized this clean-up level. The average maximum potential dose from post-remedial action use of the subject properties was less than 1 mrem per year (which is less than 0.3 percent of the typical background dose received by someone living in the United States). These limits were developed utilizing the RESRAD computer code and guidance manual (DOE/CH/8901, June 1989), as well as the ALARA principles.

This rule would also adopt the radium criteria that are already provided in 40 CFR 192. These limits for radium-226 and radium-228 are less than 5 pCi/g in the first 15 cm of the surface layer and 15 pCi/g in any subsequent 15 cm subsurface layer.

Radiological contaminants are typically removed from soil by chemical extraction, physical separation, or a combination of these two processes. The removal efficiency of these processes is highly dependent upon the type of soil.

Table 6-1 - Constituents of Concern for FEMP Soils

Constituents of Concern	Action Level
Radionuclides	
Lead-210	155 pCi/g
Radium-226	3.8 pCi/g
Radium-228	7.7 pCi/g
Thorium-228	4 pCi/g
Thorium-230	1,520 pCi/g
Thorium-232	305 pCi/g
Uranium (depleted)	35 pCi/g
Chemicals	
Antimony	1,050 μg/g
Arsenic	780 μg/g
Beryllium	16 μg/g
Lead	1,800 μg/g
Mercury	780 μg/g
Aroclor-1254	18 μg/g
Aroclor-1260	18 μg/g
Benzene	4,800 μg/g
Benzo(a)pyrene	24 μg/g
DDT	400 μg/g
Tetrachloroethene	2,700 μg/g

6.2.1.3 Petroleum Contaminants

In September and October of 1990, ten underground storage tanks (USTs), which previously contained petroleum products, were excavated at the FEMP. The contaminants identified included benzene, toluene, ethylbenzene, xylene (BTEX compounds), lead, and total petroleum hydrocarbons (TPH). This action generated approximately 3,000 cubic yards of petroleum contaminated soil. An additional 1,140 cubic yards of petroleum contaminated soil was excavated from September through November 1991.

These excavation activities did not remove all known petroleum contaminated soil at the FEMP. In several cases, contaminated soil was traced underneath buildings; which could not be removed without jeopardizing the integrity of the buildings' foundations. It was determined that these soils would be removed at a later date (e.g., when the buildings are dismantled).

Ohio EPA's policy on petroleum contaminated soil provides "clean" levels for the BTEX compounds in soil. The policy (Ohio EPA 1991) also states that the contaminated soil may be considered a solid waste under Ohio law. This determination, which is made on a case-by-case basis, is required to determine whether or not to manage the soil as a non-regulated material. The Ohio State Fire Marshall is responsible for supervising the remediation of petroleum contamination from leading USTs. The concentration limits and analytical methods for petroleum contaminants are presented in Table 6-2.

Table 6-2 - Concentration Limits and Analytical Methods for Petroleum Contaminants

Contaminant	Concentration Limit	Analytical Method
Benzene	0.006 ppm	SW846, method 8240
Toluene	4.0 ppm	SW846, method 8240
Ethylbenzene	6.0 ppm	SW846, method 8240
Xylene	28.0 ppm	SW846, method 8240
TPH	40 ppm	Method 418.1 from EPA-600/4-79-0207 for survey analysis and SW846-9071 for final analysis

Petroleum contamination is typically removed by in-situ processes, such as bioremediation, pump and treat, or soil vapor extraction. Ex-situ processes such as thermal desorption and soil washing using surfactant solutions may also be used. The wash water from the soil washing process would then require treatment by carbon adsorption. Ex-situ treatment is the most probable because the soil will require excavation to allow for removal of the radiological contaminants.

6.2.1.4 Polychlorinated Biphenyl Contaminants

Polychlorinated Biphenyls (PCBs), which are regulated by the Toxic Substances Control Act, are not predominant contaminants in soil at the FEMP. However, PCB concentrations have been detected up to

8.6 μg/g. The only two aroclors identified in soil at the FEMP are aroclor-1254 and aroclor-1260. The upper 95 percent confidence interval on the mean for aroclor-1254 is 1.1 μg/g and 2.8 μg/g for aroclor-1260.

The *Sitewide CERCLA Quality Assurance Project Plan* (WEMCO 1992) currently requires that DOE remove and containerize all soil that is discovered to contain more than 2 parts per million (ppm) of any of the aroclors. Currently, there is a only a minimal amount of this material at the FEMP.

PCBs are typically removed from soil by bioremediation, solvent extraction, thermal desorption, and soil washing. As stated above, ex-situ will most likely be done because the soil will be excavated to facilitate treatment of the radiological contaminants.

The remediation of a site with PCBs depends upon the intended future use of that site. If the site is to be utilized as a residential area, the remediation level for PCBs would be 1 ppm. However, if the site is to utilized for industrial purposes, remediation levels between 10 and 25 ppm would be considered (US EPA 1990a).

6.3 Energy Considerations

Overall energy conservation measures will be implemented during the design of the soil remediation project. Calculations of the estimated energy consumption will be included in Volume II of this CDR in subsequent submittals.

Further analysis of the project to determine energy conservation features will be performed during Title design in accordance with DOE Order 6430.1A.

6376

Conceptual Design Report for Operable Unit 5 Soil Remediation Volume II

CERCLA/RCRA Unit 5
Project Order 81
November 1993
Revision A

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio
FERMCO Subcontract No. 2-21487

PARSONS

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Fairfield, Ohio 45014

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Conceptual Design Report
for
Operable Unit 5 Soil Remediation

CONTENTS

VOLUME II

SECTION

ATTACHMENTS

SECTION 1

SCOPES OF WORK

This section will include a narrative description of all activities and/or materials within each component of the project WBS. These narrative descriptions will be combined with project drawings and outline specifications to prepare a cost estimate for the soil remediation project.

This section is currently being developed and will be included in subsequent submittals of this CDR.

SECTION 2

COST ESTIMATE DETAIL SHEETS

This section will include the following:

1) A guide to aid the reader in interpreting the cost estimate.
2) Detailed estimate sheets showing the construction and procurement costs for the project.
3) A breakdown and explanation of the Systems Engineering costs.
4) A breakdown and explanation of the estimated Design Engineering costs.
5) A breakdown and explanation of the estimated Construction Management costs.
6) Data and assumptions used to develop the Life Cycle Cost estimate.

This section is being developed and will be included in subsequent submittals of this CDR.

SECTION 3

DESIGN SUPPORTING DOCUMENTS

This section includes, or will include, the following:

1) Significant drawings prepared for the soil remediation project, including:
   (1) PFDs - Preliminary PFDs are included in this section.
   (2) Civil Site Plans are currently being prepared and will be included in subsequent submittals of this CDR.

2) Preliminary Materials and Equipment (M&E) lists. Final M&E lists will be included in subsequent submittals of this CDR.

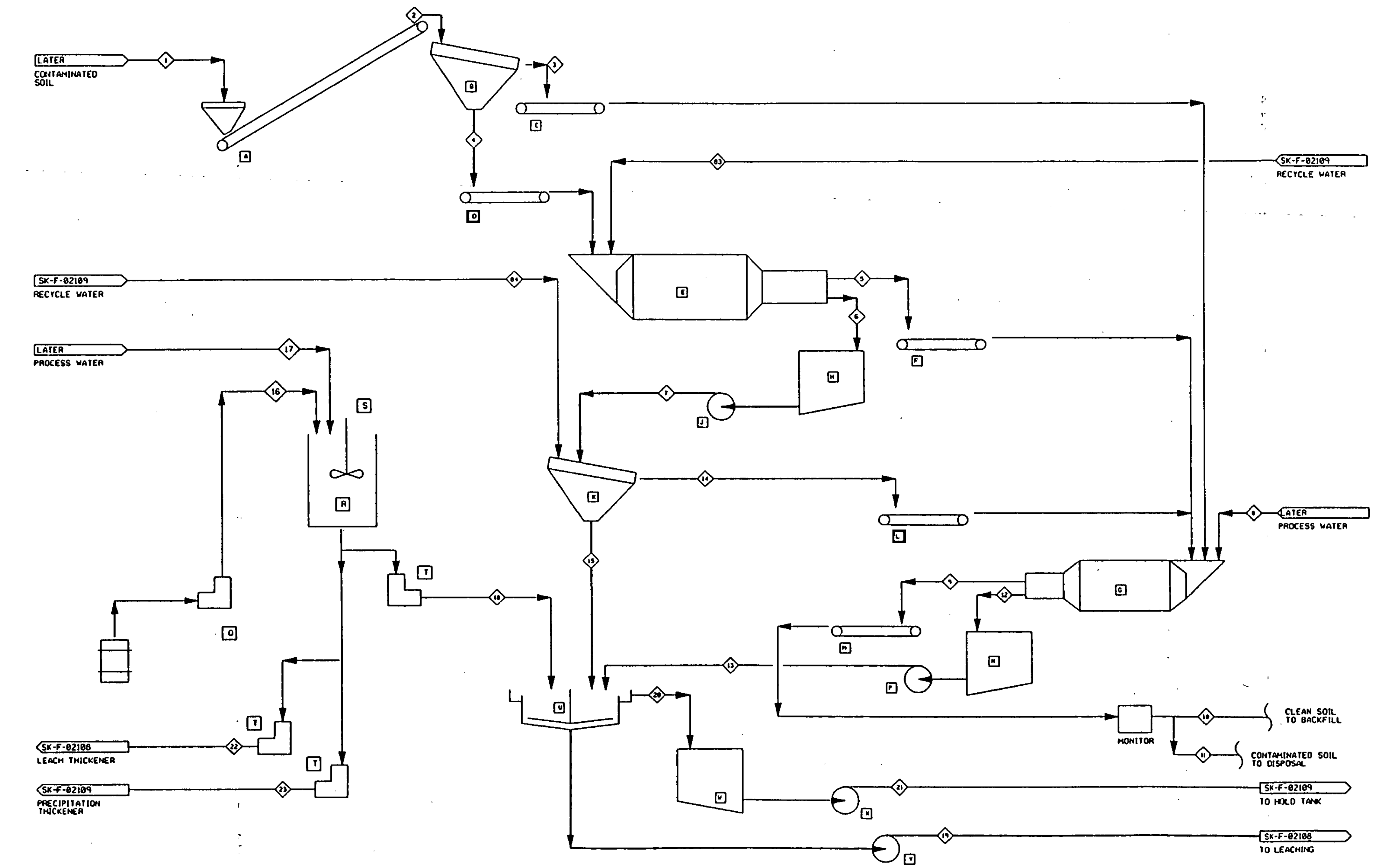
3) Outline specifications are currently being prepared and will be included in subsequent submittals of this CDR.

4) Significant supporting calculations are currently being prepared and will be included in subsequent submittals of this CDR.

DRAWING INDEX

CDR for OU-5 Soil Remediation, Volume II

Drawing No.	Revision No.	Drawing Title
SK-F-2107	A	Process - Process Flow Diagran - Screening
SK-F-2108	A	Process - Process Flow Diagran - Leaching
SK-F-2109	A	Process - Process Flow Diagran - Precipitation
SK-F-2110	A	Process - Process Flow Diagran - Reagent Unloading, Storage & Supply



NOTES

1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.
2. FLOCCULANT IS ADDED TO THE PRIMARY THICKENER, LEACH THICKENER, AND PRECIPITATE THICKENER AT A RATE OF 0.2, 0.15, AND 0.15 LB/TON DRY SOIL, RESPECTIVELY.

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	1	GRIZZLY FEED CONVEYOR
B	1	VIBRATING GRIZZLY
C	1	VIBRATING GRIZZLY OVERSIZE CONVEYOR
D	1	DRUM WASHER FEED CONVEYOR
E	1	DRUM WASHER W/TROMMEL SCREEN
F	1	DRUM WASHER DISCHARGE CONVEYOR
G	1	SECONDARY DRUM WASHER W/TROMMEL SCREEN
H	1	DRUM WASHER SUMP
J	2	DRUM WASHER SUMP PUMP
K	1	DOUBLE DECK SCREEN
L	1	DOUBLE DECK SCREEN CONVEYOR
M	1	DRUM WASHER DISCHARGE CONVEYOR
N	1	SECONDARY DRUM WASHER SUMP
P	2	SECONDARY DRUM WASHER SUMP PUMP
Q	2	FLOCCULANT TRANSFER PUMP
R	1	FLOCCULANT MAKE-UP TANK
S	1	FLOCCULANT MAKE-UP TANK AGITATOR
T	3	FLOCCULANT SUPPLY PUMP
U	1	PRIMARY THICKENER
V	2	PRIMARY THICKENER UNDERFLOW PUMP
W	1	PRIMARY THICKENER SUMP
X	2	PRIMARY THICKENER SUMP PUMP

LEGEND

MAIN PROCESS LINE

SECONDARY PROCESS LINE

REFER DWG NO.	REFERENCE DWG TITLE
SK-F-02108	LEACHING
SK-F-02109	PRECIPITATION

PRELIMINARY
NOT FOR CONSTRUCTION

REV. NO.	ISSUE OR REVISION PURPOSE - DESCRIPTION	A-E	OPERATOR
A	ISSUED FOR 50% REVIEW		

STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
COMPONENT	SOIL TO GRIZZLY FD. CONV	SOIL TO VIBRATE GRIZZLY	OVERSIZE TO SEC. DRM WASH	UNDRSIZE TO PRMRY DRM WASH	OVERSIZE TO SEC. DRM WASH	UNDRSIZE TO SUMP	SUMP TO D. D. SCREEN	CLN H_2O TO SEC. DRM WASH	SEC. DRM WASH >4 MESH	CLEAN SOIL TO BACKFILL	CONTAM. SOIL TO DISPOSAL	SECOND. DRM WASH <4 MESH	<4 MESH TO D.D. THICKENR	OVERSIZE TO SEC. DRM WASH	UNDRSIZE TO THICKENR
OPERATING TIME (hrs/day)											NEGLIBLE				
SOLIDS (DRY) (lbs/hr)	34000.0	34000.0	374.0	33626.0	867.0	32759.0	32759.0		1496.0	1496.0		NEGLIBLE	NEGLIBLE	255.0	32504.0
MOISTURE (lbs/hr)	6000.0	6000.0	66.0	5934.0	153.0	5781.0	5781.0		264.0	264.0		0.0	0.0	45.0	5736.0
WATER (lbs/hr)					218.6	27473.4	27473.4	2992.0	377.1	377.1		2897.7	2897.7	64.3	92927.0
SODIUM BICARBONATE (lbs/hr)															
SODIUM CARBONATE (lbs/hr)					15.0	585.3	585.3		2.7	2.7		6.7	6.7	15.5	2001.2
POTASSIUM PERMANGNATE (lbs/hr)															
SODIUM HYDROXIDE (lbs/hr)															
STEAM (lbs/hr)															
CARBON DIOXIDE (lbs/hr)					0.6	23.8	23.8		0.1	0.1		0.3	0.3	0.6	81.3
OTHER (lbs/hr)					2.4	93.7	93.7		0.4	0.4		1.1	1.1	2.5	320.5
MASS FLOW (lbs/hr)	40000.0	40000.0	440.0	39560.0	1256.6	66716.2	66716.2	2992.0	2140.3	2140.3		2905.8	2905.8	382.9	133570.1
(gpm)						93.3	93.3	6.0				5.8	5.8	0.5	227.2
% SOLIDS (BY WEIGHT)	85.0	85.0	85.0	85.0	70.00	49.6	49.6	0.00	70.00	70.00		0.0	0.0	70.00	24.8
SOLIDS PARTCULATE SIZE															
SPECIFIC GRAVITY (SOLIDS)	2.5	2.5	2.5	2.5	2.5	2.5	2.5		2.50	2.50			2.5	2.5	2.5
SPECIFIC GRAVITY SLURRY/WATER	2.041	2.041	2.041	2.041	1.724	1.429	1.429	1.000	1.724	1.724		1.000	1.000	1.429	1.174
TEMPERATURE (F)	68	68	68	68	84	84	84	68	68	68		68	68	68	68
URANIUM (mg/kg)															

STREAM NO.	16	17	18	19	20	21	22	23	83	84
COMPONENT	FLOCC TO MKUP TANK	CLN H_2O TOFLOCC MAKEUP	FLOCC TO PRIM THCKNR	UNDRFLOW TO LEACHING	OVERFLOW TO PRIM. SUMP	P SUMP TO HOLD TANK	FLOCC TO LEACH THICKENR	FLOCC TO PREC. THICKENR	RECYCLE WATER TO D. WASHR	R. WATER TO D.D. SCREEN
OPERATING TIME (hrs/day)									24	24
SOLIDS (DRY) (lbs/hr)	NOTE 2	NOTE 2	NOTE 2	32504.0			NOTE 2	NOTE 2		
MOISTURE (lbs/hr)				5736.0						
WATER (lbs/hr)				54628.6	44196.3	41196.3			27692.0	65518.0
SODIUM BICARBONATE (lbs/hr)									0.0	0.0
SODIUM CARBONATE (lbs/hr)				1226.2	792.9	792.9			600.3	1421.5
POTASSIUM PERMANGNATE (lbs/hr)									0.0	0.0
SODIUM HYDROXIDE (lbs/hr)									0.0	.0.0
STEAM (lbs/hr)										
CARBON DIOXIDE (lbs/hr)					82	82			24.4	0.3
OTHER (lbs/hr)				186.5	136.9	136.9			96.1	1.1
MASS FLOW (lbs/hr)				94281.3	42208.1	42208.1			28412.8	66940.9
(gpm)				148.8	84.3	84.3			56.8	133.7
% SOLIDS (BY WEIGHT)				35.0	0.00	0.00			0.0	0.0
SOLIDS PARTCULATE SIZE										
SPECIFIC GRAVITY (SOLIDS)				2.5					1.000	1.000
SPECIFIC GRAVITY SLURRY/WATER				1.266	1.000	1.000				
TEMPERATURE (F)				84	84	84			89.0	89.0
URANIUM (mg/kg)										

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. - CHAS. T. MAIN, INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

PROJECT NAME
FRD/CDR SOIL REMEDIATION CRU-5
CRU5/PO81

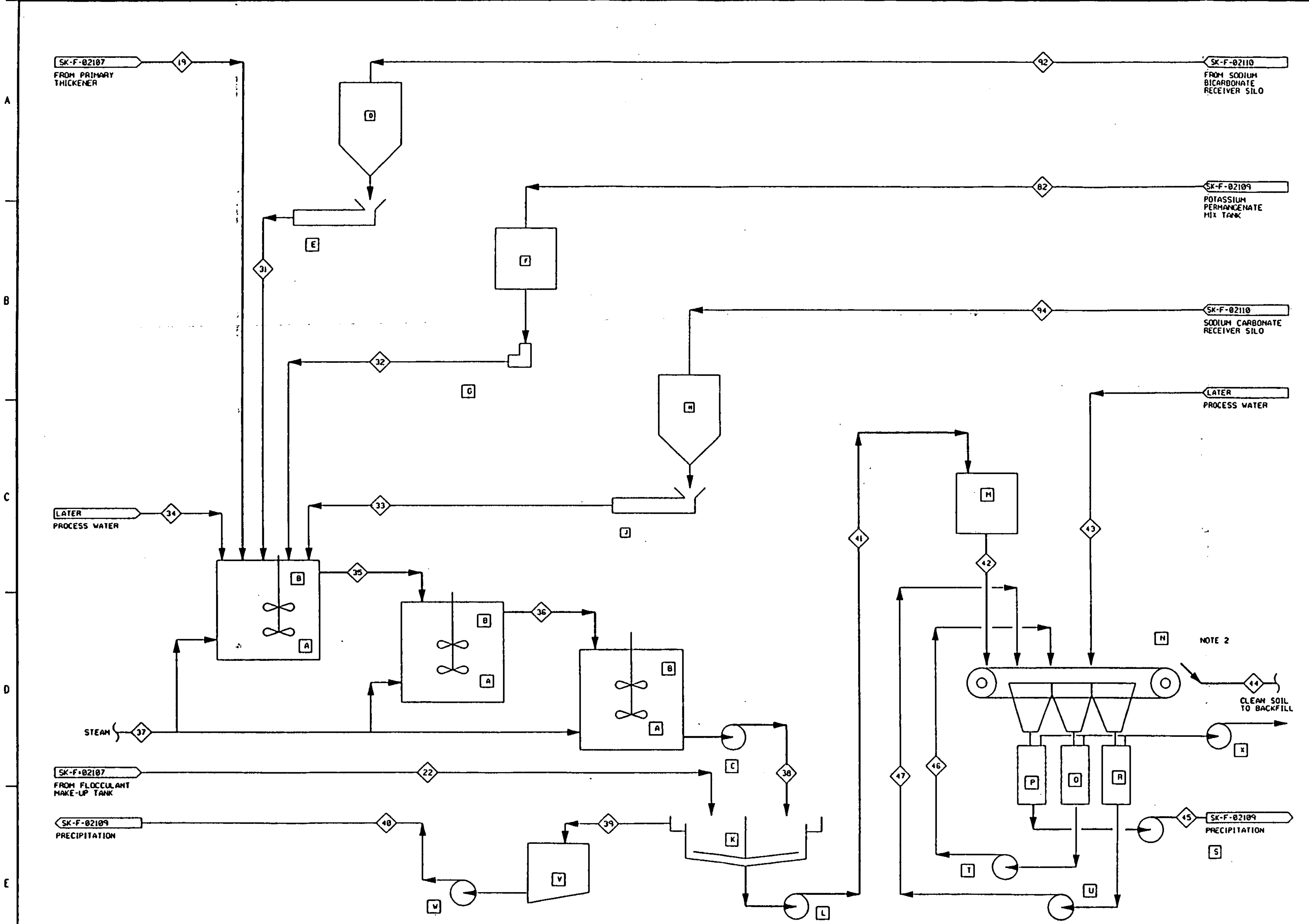
DRAWING TITLE
PROCESS
PROCESS FLOW DIAGRAM
SCREENING

DRAWN BY	DATE	DESIGNED, CHECKED BY	DATE	CHECKED BY	DATE
J. LAWSIN	08-12-93				

PLANT/BLDG. NO.	FLOOR	SCALE	CLASS
180		NONE	

SUBMITTED FOR APPROVAL — A-E — DATE
APPROVAL RECOMMENDED — OPERATING CONTRACTOR — DATE

DOE PROJECT NO.	OPER. CONTR. PROJ NO	DRAWING NO.	SHEET NO	REV. NO
	WBS 1111532 00-90701	SK-F-02107		A



STREAM NO.	19	22	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	82	92	94
COMPONENT	UNDERFLO TO LEACH	FLOCC TO LEACH THICKENR	NaHCO3 TO LEACH TANK #1	KMnO4 TO LEACH TANK #1	Na2CO3 TO LEACH TANK #1	WATER TO LEACH TANK	LEACH TANK #1/ TANK #2	LEACH TANK #2/ TANK #3	STEAM SUPPLY	LEACH TANK #3/ THKNER	THICKENR OVERFLOW TO SUMP	LEACH SUMP TO PREC	THICKENR UNDRFLOW / F HOLD	HOLD TK TO BELT FILTER	WATER TO #1 BELT FLT	CLEAN SOIL TO BACKFILL	BELT FILTER TO PREC	BELT FILTR #1 RECYCLE	BELT FILTR #2 RECYCLE	KMnO4 TO DAY TANK	NaHCO3 TO DAY TANK	Na2CO3 TO DAY TANK
OPERATING TIME (hrs/day)																					TBD	TBD
SOLIDS (DRY) (lbs/hr)	32504.0					INTER.	32504.0	31500.7		31500.7	0.0	0.0	31500.7	31500.7		31500.7	0.0	INTERNAL	INTERNAL			
MOISTURE (lbs/hr)	5736.0						5736.0	5559.0		5559.0	0.0	0.0	5559.0	5559.0		5559.0	0.0					
WATER (lbs/hr)	54628.6			1544.9			56173.4	56173.4		56173.4	30231.6	30231.6	25941.8	25941.8	78751.9	4941.3	99752.4			1544.9		
SODIUM BICARBONATE (lbs/hr)			1249.2				1249.2	0.0		0.0	0.0	0.0	0.0	0.0			0.0					
SODIUM CARBONATE (lbs/hr)	1226.2				429.0		1655.1	1248.1		1248.1	633.5	633.5	614.6	614.6			614.6					
POTASSIUM PERMANGNATE (lbs/hr)				100.0			100.0	0.0		0.0	0.0	0.0	0.0	0.0			0.0			100.0		
SODIUM HYDROXIDE (lbs/hr)																						
STEAM (lbs/hr)									1100.0													
CARBON DIOXIDE (lbs/hr)																						
OTHER (lbs/hr)	186.5						306.8	3143.3		3143.4	1574.5	1574.5	1568.7	1568.7		55	1513.7					
MASS FLOW (lbs/hr)	94281.3		1249.2	1644.9	429.0		97624.5	97624.5	1100.0	96624.6	32439.6	32439.6	65184.8	65184.8	78751.9	42056.0	101880.7			1644.9		
(gpm)	148.8						154.8	155.5		155.5	64.8	64.8	91.1	91.1	157.3		203.5			3.3		
% SOLIDS (BY WEIGHT)	35.0						34.4	33.8		33.8	0.0	0.0	50.0	50.0		75.0	0.0			0.0		
SOLIDS PARTCULATE SIZE							2.5	2.5		2.5			2.5	2.5		2.5	2.5					
SPECIFIC GRAVITY (SOLIDS)	2.5						1.260	1.264		1.254	1.000	1.000	1.429	1.429	1.000	1.819	1.000					
SPECIFIC GRAVITY SLURRY/WATER	1.266																			1.000		
TEMPERATURE (F)	84		68.0	68.0	68.0	68.0	104.0	111.0	250.0	111.0	111.0	111.0	111.0	111.0	68.0	81.0	81.0			89.0		
URANIUM (mg/kg)																						

NOTES

1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.
2. TWO BELT FEEDERS ARE USED. MATERIAL BALANCE REFLECTS TOTAL FLOW TO BOTH BELT FEEDERS. EACH FILTER WILL HANDLE ONE-HALF THE TOTAL FLOW.

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	3	REACTOR SCRUBBERS
B	3	REACTOR SCRUBBER AGITATORS
C	2	REACTOR SCRUBBER TRANSFER PUMP
D	1	SODIUM BICARBONATE DAY TANK
E	1	SODIUM BICARBONATE FEEDER
F	1	POTASSIUM PERMANGENATE DAY TANK
G	1	POTASSIUM PERMANGENATE METERING PUMP
H	1	SODIUM CARBONATE DAY TANK
J	1	SODIUM CARBONATE FEEDER
K	1	LEACH THICKENER
L	2	LEACH THICKENER TRANSFER PUMP
M	1	LEACH BELT FILTER FEED TANK
N	2	LEACH BELT FILTER
P	2	FILTRATE TANK NO. 1
Q	2	FILTRATE TANK NO. 2
R	2	FILTRATE TANK NO. 3
S	2	FILTRATE PUMP NO. 1
T	2	FILTRATE PUMP NO. 2
U	2	FILTRATE PUMP NO. 3
V	1	LEACH THICKENER SUMP
W	2	LEACH THICKENER SUMP PUMP
X	2	LEACH BELT FILTER VACUUM PUMP

LEGEND

MAIN PROCESS LINE
SECONDARY PROCESS LINE
FUTURE PIPING
FUTURE EQUIPMENT

REFER DWG NO.	REFERENCE DWG TITLE
SK-F-02107	SCREENING
SK-F-02109	PRECIPITATION
SK-F-02110	REAGENT UNLOADING, STORAGE, AND SUPPLY

PRELIMINARY
NOT FOR CONSTRUCTION

REV. NO.	ISSUE OR REVISION PURPOSE - DESCRIPTION	A-E	PREPARER (INITIALS AND DATE)
A	ISSUED FOR 50% REVIEW		

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. - CHAS. T. MAIN, INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

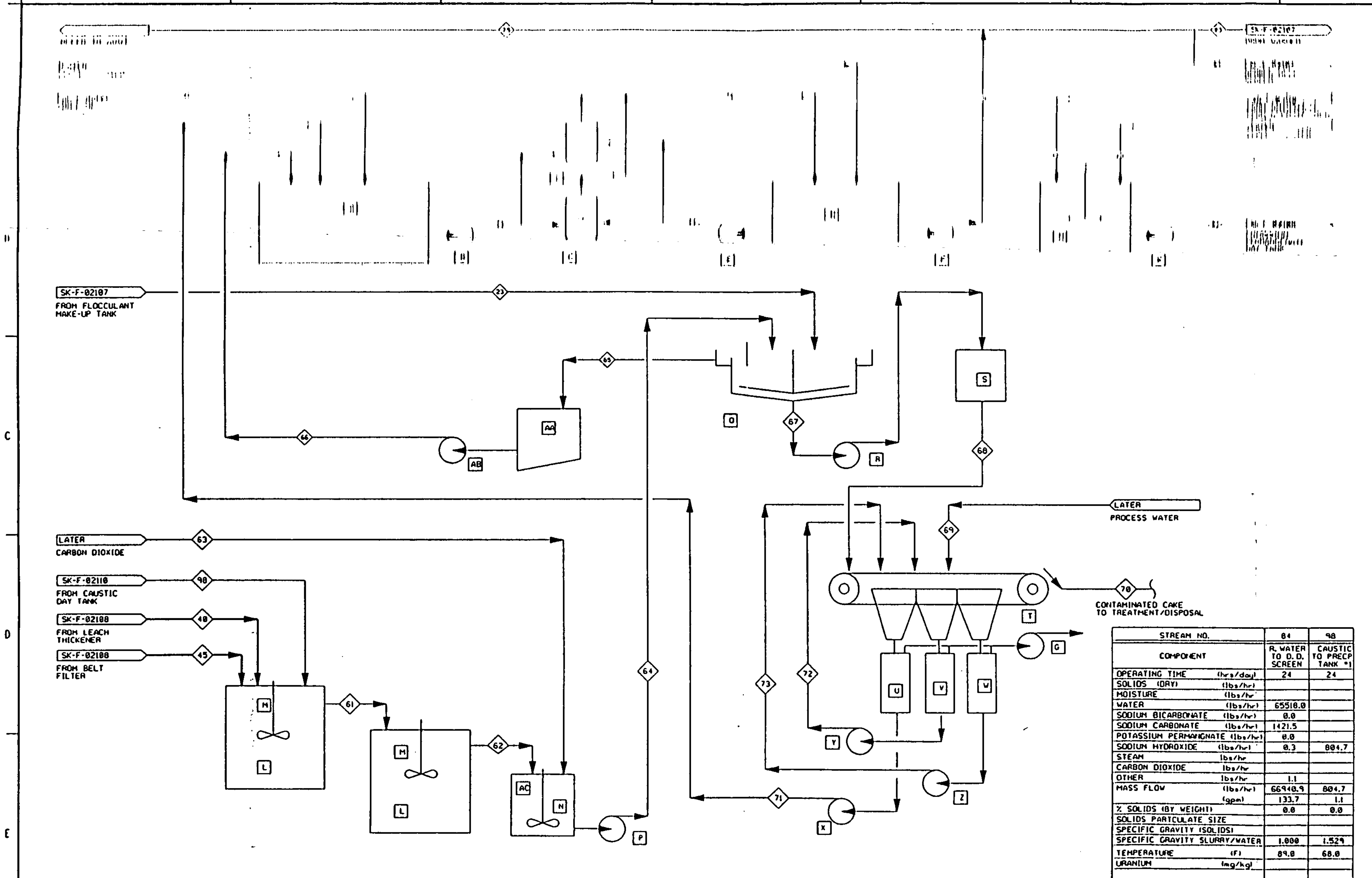
PROJECT NAME
FDR/CDR SOIL REMEDIATION CRU-5
CRU5/PO81

DRAWING TITLE
PROCESS
PROCESS FLOW DIAGRAM
LEACHING

DRAWN BY: J. LAWSON | DATE: 08-12-93 | DESIGNED, CHECKED BY | DATE | CHECKED BY | DATE
PLANT/BLDG NO. | FLOOR | SCALE: NONE | CLASS
SUBMITTED FOR APPROVAL | APPROVAL RECOMMENDED
A-E | DATE | OPERATING CONTRACTOR | DATE
DOE PROJECT NO. | OPER. CONTR. PROJ NO: WBS 1111532 00-90701 | DRAWING NO.: SK-F-02108 | SHEET NO. | REV. NO: A

TEMPERATURE (F)	68.0	68.0	68.0	
URANIUM (mg/kg)				

DOE PROJECT NO. | OPER CONTR. PROJ NO. VBS 111532 00-90701 | DRAWING NO. SK-F-02110 | SHEET NO. | REV. NO. A



STREAM NO.	84	98
COMPONENT	R. WATER TO O.D. SCREEN	CAUSTIC TO PRECP TANK *1
OPERATING TIME (hrs/day)	24	24
SOLIDS (DRY) (lbs/hr)		
MOISTURE (lbs/hr)		
WATER (lbs/hr)	65518.0	
SODIUM BICARBONATE (lbs/hr)	0.0	
SODIUM CARBONATE (lbs/hr)	1421.5	
POTASSIUM PERMANGNATE (lbs/hr)	0.0	
SODIUM HYDROXIDE (lbs/hr)	0.3	804.7
STEAM lbs/hr		
CARBON DIOXIDE lbs/hr		
OTHER lbs/hr	1.1	
MASS FLOW (lbs/hr)	66940.9	804.7
(gpm)	133.7	1.1
% SOLIDS (BY WEIGHT)	0.0	0.0
SOLIDS PARTICULATE SIZE		
SPECIFIC GRAVITY (SOLIDS)		
SPECIFIC GRAVITY SLURRY/WATER	1.000	1.529
TEMPERATURE (F)	89.0	68.0
URANIUM (mg/kg)		

STREAM NO.	21	23	40	45	61	62	63	64	65	66	67	68
COMPONENT	P SUMP TO HOLD TANK	FLOC TO PREC THICKENR	LEACH SUMP TO PREC.	BELT FILTR TO PRECIP	PREC TK *1 TO PR TK *2	PREC TK *2 TO SUMP	CO2 TO REGEN TANK	REGEN TANK TO THICKENR	THICKENR OVERFLOW TO SUMP	THICKENR SUMP TO W W HOLD	THICKENR UNDRFLOW TO F HLD	HOLD TK TO BELT FILTER
OPERATING TIME (hrs/day)					24	24	24	24	24	24	24	24
SOLIDS (DRY) (lbs/hr)			0.0	0.0	0.0	0.0		0.0	0.0	0.0		0.0
MOISTURE (lbs/hr)			0.0	0.0		0.0		0.0	0.0	0.0		0.0
WATER (lbs/hr)	41196.3		30231.6	99752.4	129984.0	129984.0		130013.9	126985.2	126985.2	3028.6	3028.6
SODIUM BICARBONATE (lbs/hr)			0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
SODIUM CARBONATE (lbs/hr)	729.9		633.5	614.6	2829.9	2829.9		3003.8	2935.1	2935.1	68.7	68.7
POTASSIUM PERMANGNATE (lbs/hr)			0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
SODIUM HYDROXIDE (lbs/hr)					131.3	131.3		0.0	0.0	0.0	0.0	0.0
STEAM lbs/hr												
CARBON DIOXIDE lbs/hr	82						144.4	72.2	72.2	72.2		
OTHER lbs/hr	136.9		1574.5	1513.7	2101.9	2101.9		2101.9	460.7	460.7	1641.2	1641.2
MASS FLOW (lbs/hr)	42208.1		32439.6	101880.7	135047.1	135047.1	144.4	135191.8	130453.2	30453.2	4738.5	4738.5
(gpm)	84.3		64.8	203.5	269.8	269.8		270.1	260.6	260.6	7.5	7.5
% SOLIDS (BY WEIGHT)	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	35.0	35.0
SOLIDS PARTICULATE SIZE												
SPECIFIC GRAVITY (SOLIDS)				2.5	2.5	2.5		2.5	1.000	1.000	1.266	1.266
SPECIFIC GRAVITY SLURRY/WATER	1.000		1.000	1.000	1.000	1.000		1.000				
TEMPERATURE (F)			111.0	81.0	68.0	84.0		84.0	90.0	90.0	90.0	90.0
URANIUM (mg/kg)												

STREAM NO.	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
COMPONENT	CLN WTR TO PREC BLT FLTR	CNT CAKE TO DISP/ TREATMNT	BLT FLTR TO WASTE WATER	BELT FLTR *1 RECYCLE	BELT FLTR *2 RECYCLE	WST WATR TO MEDIA FILTERS	WST WATR TO RCYCL STORAGE	CLEAN WATER MAKEUP	MEDIA FILTERS BACKWASH	RECYCLE STORAGE DISCHARG	RECYCLE BLEED TO AWWT	PR H-O TO KMnO4 MIX TANK	DRY KMnO4 TO MIX TANK	KMnO4 TO DAY TANK	RECYCLE WATER TO D. WASHR
OPERATING TIME (hrs/day)	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
SOLIDS (DRY) (lbs/hr)		0.0	0.0	INTERNAL	INTERNAL	0.0	0.0	INTERMIT	INTERMIT	0.0	0.0				
MOISTURE (lbs/hr)	4076.9	0.0	0.0			0.0	0.0			0.0	0.0				
WATER (lbs/hr)		698.9	6406.6			174588.1	174588.1			174588.1	81378.1	1544.9		1544.9	27692.0
SODIUM BICARBONATE (lbs/hr)			0.0			0.0	0.0			0.0	0.0				0.0
SODIUM CARBONATE (lbs/hr)			68.7			3796.7	3796.7			3796.7	1775.0				600.3
POTASSIUM PERMANGNATE (lbs/hr)			0.0			0.0	0.0			0.0	0.0		100.0	100.0	0.0
SODIUM HYDROXIDE (lbs/hr)			0.0			0.0	0.0			0.0	0.0				.0.0
STEAM lbs/hr															
CARBON DIOXIDE lbs/hr						96.8	96.8			96.8	72.1				24.4
OTHER lbs/hr		1630.8	10.5			381.4	381.4			381.4	284.2				96.1
MASS FLOW (lbs/hr)	4076.9	2329.7	6485.8			178863.0	178863.0			178863.0	83509.4	1544.9	100.0	1644.9	28412.8
(gpm)	8.1	4.7	13.0			357.3	357.3			357.3	166.8	3.1		3.3	56.8
% SOLIDS (BY WEIGHT)		70.0	0.0			0.0	0.0			0.0	0.0	0.0	100.0	0.0	0.0
SOLIDS PARTICULATE SIZE															
SPECIFIC GRAVITY (SOLIDS)	1.000	1.000													
SPECIFIC GRAVITY SLURRY/WATER			1.000			1.000	1.000			1.000	1.000	1		1	1.000
TEMPERATURE (F)	68.0	78.0	78.0			89.0	89.0			89.0	89.0	68.0	68.0	68.0	89.0
URANIUM (mg/kg)															

NOTES

1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.

O	1	PRECIPITATE THICKENER
R	2	PRECIPITATE THICKENER TRANSFER PUMP
S	1	PRECIPITATE BELT FILTER FEED TANK
T	1	PRECIPITATE BELT FILTER
U	1	FILTRATE TANK NO. 4
V	1	FILTRATE TANK NO. 5
W	1	FILTRATE TANK NO. 6
X	1	FILTRATE PUMP NO. 4
Y	1	FILTRATE PUMP NO. 5
Z	1	FILTRATE PUMP NO. 6
AA	1	PRECIPITATE THICKENER SUMP
AB.	2	PRECIPITATION THICKENER SUMP PUMP
AC	1	Na_2CO_3 REGENERATION TANK AGITATOR

LEGEND

MAIN PROCESS LINE

SECONDARY PROCESS LINE

REFER DWG NO.	REFERENCE DWG TITLE
SK-F-02107	SCREENING
SK-F-02108	LEACHING
SK-F-02110	REAGENT UNLOADING, STORAGE & SUPPLY

PRELIMINARY
NOT FOR CONSTRUCTION

REV. NO.	ISSUE OR REVISION PURPOSE - DESCRIPTION	A-E	OPERATOR	
A	ISSUED FOR 50% REVIEW			

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. • CHAS. T. MAIN, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

PROJECT NAME
FRO/CDR SOIL REMEDIATION CRU-5
CRU5/P081

DRAWING TITLE
PROCESS
PROCESS FLOW DIAGRAM
PRECIPITATION

DRAWN BY: J. LAWSON | DATE: 08-12-93 | DESIGNED, CHECKED BY | DATE | CHECKED BY | DATE
SCALE: NONE
SUBMITTED FOR APPROVAL | APPROVAL RECOMMENDED
A-E DATE | OPERATING CONTRACTOR DATE
DOE PROJECT NO. | OPER CONTR. PROJ NO. VBS 111532 00-90701 | DRAWING NO. SK-F-02109 | SHEET NO. | REV. NO. A

skf02110.m(3338.ws310) po81@ws310. Mon Nov 8 09:35:25 CST 1993

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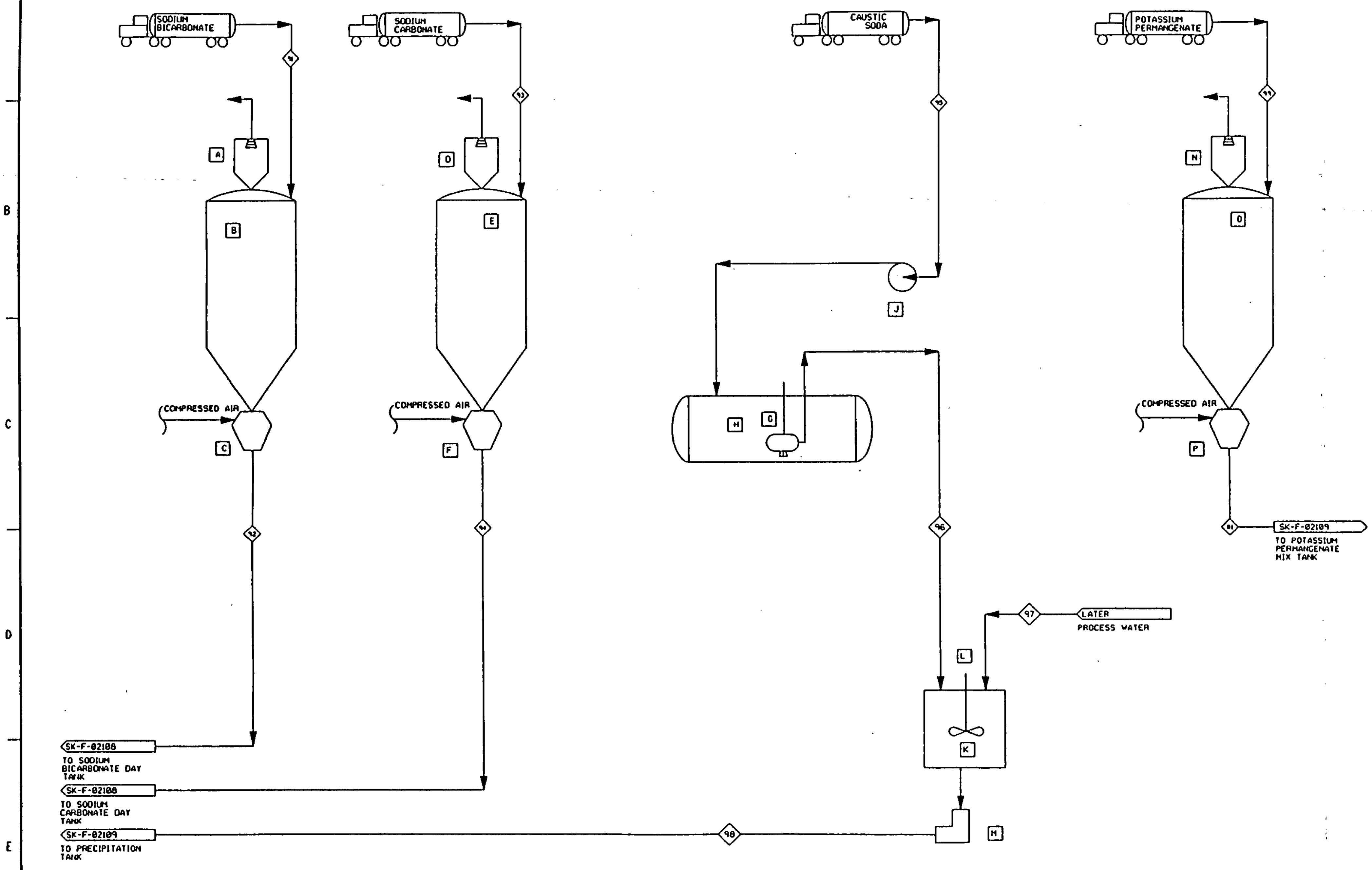

STREAM NO.	81	91	92	93	94	95	96	97	98
COMPONENT	DRY KMnO4 TO MIX TANK	NaHCO3 UNL'D TO STORAGE	NaHCO3 TO DAY TANK	Na2CO3 UNLOAD TO SILO	Na2CO3 TO DAY TANK	CAUSTIC UNL'D TO STORAGE	CAUSTIC TO MAKE-UP TANK	CL'N H2O TO CAUST MAKEUP	CAUSTIC TO PREC TANKS
OPERATING TIME (hrs/day)		TBD	TBD	TBD	TBD	TBD		TBD	
SOLIDS (DRY) (lbs/hr)									
MOISTURE (lbs/hr									
WATER (lbs/hr)									
SODIUM BICARBONATE (lbs/hr)									
SODIUM CARBONATE (lbs/hr)									
POTASSIUM PERMANGNATE (lbs/hr)	100.0								
SODIUM HYDROXIDE (lbs/hr)							3825.0		804.7
STEAM (lbs/hr)									
CARBON DIOXIDE (lbs/hr)									
OTHER (lbs/hr)									
MASS FLOW (lbs/hr)	100.0						3825.0		804.7
(gpm)							5.0		1.1
% SOLIDS (BY WEIGHT)									
SOLIDS PARTICULATE SIZE									
SPECIFIC GRAVITY (SOLIDS)							1.529		1.529
SPECIFIC GRAVITY SLURRY/WATER									
TEMPERATURE (F)	68.0						68.0		68.0
URANIUM (mg/kg)									

NOTES

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	1	SODIUM BICARBONATE BIN VENT FILTER
B	2	SODIUM BICARBONATE SILO
C	1	SODIUM BICARBONATE BLOW POT/LOAD CELLS
D	1	SODIUM CARBONATE BIN VENT FILTER
E	2	SODIUM CARBONATE SILO
F	1	SODIUM CARBONATE BLOW POT/LOAD CELLS
G	2	CAUSTIC SODA SUPPLY PUMP
H	1	CAUSTIC SODA STORAGE TANK
J	2	CAUSTIC SODA UNLOADING PUMP
K	1	CAUSTIC SODA DAY TANK
L	1	CAUSTIC SODA DAY TANK AGITATOR
M	2	CAUSTIC SODA METERING PUMP
N	1	POTASSIUM PERMANGENATE BIN VENT FILTER
O	1	POTASSIUM PERMANGENATE SILO
P	1	POTASSIUM PERMANGENATE BLOW POT/LOAD CELLS

LEGEND

MAIN PROCESS LINE

SECONDARY PROCESS LINE

REFER DWG NO.	REFERENCE DWG TITLE
SK-F-02108	LEACHING
SK-F-02109	PRECIPITATION

PRELIMINARY
NOT FOR CONSTRUCTION

REV. NO	ISSUE OR REVISION PURPOSE - DESCRIPTION	A-E	OPERATOR
A	ISSUED FOR 50% REVIEW		

INITIALS AND DATE

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. • CHAS. T. MAIN, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

PROJECT NAME
FRD/CDR SOIL REMEDIATION CRU-5
CRU5/PO81

DRAWING TITLE
PROCESS
PROCESS FLOW DIAGRAM
REAGENT UNLOADIING, STORAGE & SUPPLY

DRAWN BY	DATE	DESIGNED/CHECKED BY	DATE	CHECKED BY	DATE
J. LAWSON	08-31-93				

PLANT/BLDG NO.	FLOOR	SCALE	CLASS
180		NONE	

SUBMITTED FOR APPROVAL | APPROVAL RECOMMENDED

A-E DATE | OPERATING CONTRACTOR DATE

DOE PROJECT NO.	OPER. CONTR. PROJ. NO.	DRAWING NO.	SHEET NO.	REV. NO
	WBS 1111532 00-90701	SK-F-02110		A

PARSONS
ERA PROJECT

MATERIAL AND EQUIPMENT LIST

CRU-5 PO-81
Date: November 8, 1993

Subject: SCREENING
Project Title: FRD/CDR Soil Remediation CRU-5
Discipline:

20 Tons/Hr

Mark	Sketch No.	Qty.	Equipment Name	Description	Est. HP
A	SK-F-02107	1	Grizzly Feed Conveyor	18" W	
B	SK-F-02107	1	Vibrating Grizzly	4' x 6' Rectangular w/ 6" Screen	
C	SK-F-02107	1	Vibrating Grizzly O'size Conv.	18" W	
D	SK-F-02107	1	Drum Washer Feed Conveyor	18" W	
E	SK-F-02107	1	Drum Washer/Trommel Screen	8'ϕ x 10' Long; 8'ID x 6' Long Screen	
F	SK-F-02107	1	Drum Washer Discharge Conv.	18" W	
G	SK-F-02107	1	Sec Drum Washer/Trommel Scr	4'ϕ x 6' Long; 4'ID x 4' Long Screen	
H	SK-F-02107	1	Drum Washer Sump	300 Gallons	
J	SK-F-02107	2	Drum Washer Sump Pump	60 GPM	
K	SK-F-02107	1	Double Deck Screen	4' x 8' (3/4" and 4 Mesh)	
L	SK-F-02107	1	Double Deck Screen Conveyor	16" W Belt	
M	SK-F-02107	1	Drum Washer Discharge Conv.	16" W Belt	
N	SK-F-02107	1	Secondary Drum Washer Sump	50 Gallons	
P	SK-F-02107	2	Sec Drum Washer Sump Pump	10 GPM	
Q	SK-F-02107	3	Flocculant Transfer Pump	5 GPM	
R	SK-F-02107	1	Flocculant Make-up Tank	150 Gallons	
S	SK-F-02107	1	Flocculant Make-up Tank Agit.		

000068

6376

PARSONS
ERA PROJECT

MATERIAL AND EQUIPMENT LIST

CRU-5 PO-81
Date: November 8, 1993

Subject: SCREENING (cont)
Project Title: FRD/CDR Soil Remediation CRU-5
Discipline:

20 Tons/Hr

Mark	Sketch No.	Qty.	Equipment Name	Description	Est. HP
T	SK-F-02107	3	Flocculant Supply Pump	3 GPM (0.5 to 3 GPM)	
U	SK-F-02107	1	Primary Thickener	85'ϕ	
V	SK-F-02107	2	Primary Thickener U'flow Pump	150 GPM	
W	SK-F-02107	1	Primary Thickener Sump	250 Gallons	
X	SK-F-02107	2	Primary Thickener Sump Pump	90 GPM	

000069

PARSONS
ERA PROJECT

MATERIAL AND EQUIPMENT LIST

CRU-5 PO-81
Date: November 8, 1993

Subject: LEACHING
Project Title: FRD/CDR Soil Remediation CRU-5
Discipline:

20 Tons/Hr

Mark	Sketch No.	Qty.	Equipment Name	Description	Est. HP
A	SK-F-02108	3	Reactor Scrubbers	8000 Gallons (each) 8' x 16' x 10'H	
B	SK-F-02108	3	Reactor Scrubber Agitators		
C	SK-F-02108	2	Reactor Scrubber X-fer Pumps	160 GPM	
D	SK-F-02108	1	$NaHCO_3$ Day Tank	15 Tons, 8'ϕ x 12'H	
E	SK-F-02108	1	$NaHCO_3$ Feeder		
F	SK-F-02108	1	$KMnO_4$ Day Tank	5000 Gallons; 10'ϕ x 12'H	
G	SK-F-02108	1	$KMnO_4$ Metering Pump	5 GPM	
H	SK-F-02108	1	Sodium Carbonate Day Tank	5.5 Ton; 6'ϕ x 8'H	
J	SK-F-02108	1	Sodium Carbonate Feeder	0.5 to 1 Tons/Hour	
K	SK-F-02108	1	Leach Residue Thickener	85'ϕ	
L	SK-F-02108	2	Lch Res Thickener X-fer Pump	100 GPM Diaphragm	
M	SK-F-02108	1	Lch Res Belt Filter Feed Tank	500 Gallons; 4.5'ϕ x 6'H	
N	SK-F-02108	2	Leach Residue Belt Filter	325 Ft^2; 12'8"W x 52'L x 9'6"H	
P	SK-F-02108	2	Filtrate Tank No. 1	650 Gallons; 4'ϕ x 6'H	
Q	SK-F-02108	2	Filtrate Tank No. 2	650 Gallons; 4'ϕ x 6'H	
R	SK-F-02108	2	Filtrate Tank No. 3	650 Gallons; 4'ϕ x 6'H	
S	SK-F-02108	2	Filtrate Pump No. 1	110 GPM Centrifugal	

000070

6376

PARSONS
ERA PROJECT

MATERIAL AND EQUIPMENT LIST

000071

CRU-5 PO-81
Date: November 8, 1993

Subject: LEACHING (cont)
Project Title: FRD/CDR Soil Remediation CRU-5
Discipline:

20 Tons/Hr

Mark	Sketch No.	Qty.	Equipment Name	Description	Est. HP
T	SK-F-02108	2	Filtrate Pump No. 2	55 GPM	
U	SK-F-02108	2	Filtrate Pump No. 3	55 GPM	
V	SK-F-02108	1	Leach Thickener Sump	200 Gallons; 3.5' x 3.5' x 5'	
W	SK-F-02108	2	Leach Thickener Sump Pump	60 GPM Centrifugal	
X	SK-F-02108	1	Leach Belt Filter Vacuum Pump	1300 ft^3/min	

PARSONS
ERA PROJECT

MATERIAL AND EQUIPMENT LIST

CRU-5 PO-81
Date: November 8, 1993

Subject: PRECIPITATION
Project Title: FRD/CDR Soil Remediation CRU-5
Discipline:

20 Tons/Hr

Mark	Sketch No.	Qty.	Equipment Name	Description	Est. HP
A	SK-F-02109	1	Hold Tank	20'ϕ x 24'H	
B	SK-F-02109	2	Hold Tank Transfer Pump	360 GPM Centrifugal	
C	SK-F-02109	2	Multi-media Filter	360 GPM; 8'ϕ x 6'H	
D	SK-F-02109	1	Recycle Water Storage Tank	20'ϕ x 24'H	
E	SK-F-02109	2	Backwash Pump	100 GPM	
F	SK-F-02109	2	Recycle Water Supply Pump	360 GPM	
G	SK-F-02109	1	Prec. Belt Filter Vacuum Pump	200 ft^3/min	
H	SK-F-02109	1	$KMnO_4$ Mix Tank	10,000 Gallons	
J	SK-F-02109	1	$KMnO_4$ Mix Tank Agitator		
K	SK-F-02109	2	$KMnO_4$ Supply Pump	50 GPM	
L	SK-F-02109	2	Precipitation Tank	8'ϕ x 10'H	
M	SK-F-02109	2	Precipitation Tank Mixer		
N	SK-F-02109	1	Na_2CO_3 Regeneration Tank	6'ϕ x 8'H	
P	SK-F-02109	2	Na_2CO_3 Regeneration Tk Pump	280 GPM Centrifugal	
Q	SK-F-02109	1	Precipitate Thickener	20' Diameter	
R	SK-F-02109	2	Prec. Thickener X-fer Pump	15 GPM Diaphragm	
S	SK-F-02109	1	Prec. Belt Filter Feed Tank	75 Gallons	

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Doc. Control No.:
Rev. No.:

000073

PARSONS
ERA PROJECT

MATERIAL AND EQUIPMENT LIST

CRU-5 PO-81
Date: November 8, 1993

Subject: PRECIPITATION (cont)
Project Title: FRD/CDR Soil Remediation CRU-5
Discipline:

20 Tons/Hr

Mark	Sketch No.	Qty.	Equipment Name	Description	Est. HP
T	SK-F-02109	1	Precipitate Belt Filter	50 ft^2 8'W x 22'L x 7.5'H	
U	SK-F-02109	1	Filtrate Tank No. 4	150 Gallons	
V	SK-F-02109	1	Filtrate Tank No. 5	150 Gallons	
W	SK-F-02109	1	Filtrate Tank No. 6	150 Gallons	
X	SK-F-02109	1	Filtrate Pump No. 4	20 GPM	
Y	SK-F-02109	1	Filtrate Pump No. 5	10 GPM	
Z	SK-F-02109	1	Filtrate Pump No. 6	10 GPM	
AA	SK-F-02109	1	Precipitate Thickener Sump	800 Gallons	
AB	SK-F-02109	2	Prec. Thickener Sump Pump	260 GPM	
AC	SK-F-02109	1	Na_2CO_3 Regen Tk Agitator		

PARSONS
ERA PROJECT

MATERIAL AND EQUIPMENT LIST

CRU-5 PO-81
Date: November 8, 1993

Subject: REAGENT STORAGE
Project Title: FRD/CDR Soil Remediation CRU-5
Discipline:

20 Tons/Hr

Mark	Sketch No.	Qty.	Equipment Name	Description	Est. HP
A	SK-F-02110	1	$NaHCO_3$ Bin Vent Filter		
B	SK-F-02110	2	$NaHCO_3$ Silo	100 Tons Capacity; 10'W x 10'L x 26'H	
C	SK-F-02110	1	$NaHCO_3$ Blow Pot/Load Cells	1.5 Tons	
D	SK-F-02110	1	Na_2CO_3 Bin Vent Filter		
E	SK-F-02110	2	Na_2CO_3 Silo	100 Tons Capacity; 10'W x 10'L x 26'H	
F	SK-F-02110	1	Na_2CO_3 Blow Pot/Load Cells	1.5 Tons	
G	SK-F-02110	2	Caustic Soda Supply Pump	30 GPM Submerged	
H	SK-F-02110	1	Caustic Soda Storage Tank	10,000 Gallons	
J	SK-F-02110	2	Caustic Soda Unloading Pump		
K	SK-F-02110	1	Caustic Soda Day Tank	1600 Gallons	
L	SK-F-02110	1	Caustic Soda Day Tk. Agitator		
M	SK-F-02110	2	Caustic Soda Metering Pump	0.5 to 2.5 GPM	
N	SK-F-02110	1	$KMnO_4$ Bin Vent Filter		
O	SK-F-02110	1	$KMnO_4$ Silo	100 Tons Capacity; 10'W x 10'L x 26'H	
P	SK-F-02110	1	$KMnO_4$ Blow Pot/Load Cells		

SECTION 4

OTHER SUPPORTING DOCUMENTS

This section will include any other supporting documents used to prepare the conceptual design cost estimate.

If no other supporting documents are used, this section will be deleted from subsequent submittals of this CDR.

SECTION 5

REFERENCES

(DOE 1992a) United States Department of Energy, January 1992. *Initial Screening of Alternatives for Operable Unit 5.* DOE: Fernald Field Office.

(DOE 1992b) ----------, August 1992. *Treatability Study Work Plan for Operable Unit 5 Soil Washing*. DOE: Fernald Field Office.

(DOE 1993) ----------, March 1993. *Sitewide Characterization Report.* DOE: Fernald Field Office.

(FERMCO 1993) Fernald Environmental Restoration Management Corporation, September 27, 1993. *RI/FS and Remedial Action Schedule Report, CERCLA/RCRA Unit 5, Environmental Media.* FERMCO: Fernald.

(PNL 1988) Pacific Northwest Laboratory, June 1988. *Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels That Are As Low As Reasonably Achievable (ALARA).* Springfield, Virginia: U.S. Department of Commerce NTIS.

ATTACHMENT A

PROJECT ORDER 81 SCOPE OF WORK

Fernald Environmental
FERMCO
Restoration Management Corporation

FY-1993

PRELIMINARY

REQUEST FOR PROJECT PROPOSAL

PROJECT ORDER NO. 81 **REVISION** 1

Contract No. 2-21487

TO: Ralph M. Parsons, Inc.
Attn: Mr. Richard F. Duda
6120 South Gilmore Road
Fairfield Executive Center
Fairfield, Ohio 45014

Project Title: Conceptual Design Report Document for CRU 5 Soil Remediation

Provide The Following Engineering Services:

Prepare a cost proposal to provide labor, equipment and materials to perform engineering support per the attached revised scope of work.

There is no increased funding in Revision one. Funding remains at $300,000.

Complete Engineering Services: October 1993
Project Order Limitation of Funds: $300,000
Funding Source: EW-20 (See Page 2)
The negotiated labor hours will be established in the negotiated final project order.

L. Henke Date 3/1/93
Procurement and Material Management

FERMCO CRU DIRECTOR: Date: 2/23/93
PCC: Date: 2/23/93
COTR: J R Hughes Date: 2-23-93
COR: Date: 2-23-93

Point of Contact: D. M. Garrick, Ext. 6180
Technical Monitor: D. J. Brettschneider, Ext. 6101

Fernald Environmental
FERMCO
Restoration Management Corporation

FY-1993

PRELIMINARY

Fiscal Year	DPLH	Funding
1993		$ 300,000
TOTALS		$ 300,000

Activity	Funding Source	WBS	Charge №	Net Change	Funding
Prepare Cost Proposal	EW20	1.1.1.1.5.3.2	RJF01	$ 0	$ 20,000
Prepare FRD/CDR	EW20	1.1.1.1.5.3.2	RJF01	$ 0	$ 280,000
TOTAL				$ 0	$ 300,000

PO81R1

000079

REVISED
STATEMENT OF WORK

CONCEPTUAL DESIGN REPORT
for
CERCLA/RCRA UNIT 5 SOIL REMEDIATION

1. Purpose

The purpose of this revision to Project Order (P.O.) 81 is for Parsons to prepare a Conceptual Design Report (CDR) incorporating selected elements of a Functional Requirements Documents (FRD), a soil characterization and quantification analysis, and a treatment system alternatives evaluation. This revised statement of work will downscope the earlier Request for Proposal (RFP), Revision 0, proposed scope of work and establish a revised project schedule.

2. Task Description

Attachment 1 provides a comparative study of the Parsons draft P.O. 81 proposal (shown as P.O. 81, Revision 0 on attachment) and the revised P.O. 81 approach. The following work packages will be provided by Parsons and selectively integrated into a single CDR document with deliverables outlined below in Section 4.0:

- project engineering and management support
- P.O. 81 proposal preparation
- soil characterization and quantification
- treatment system alternatives evaluation
- functional requirements
- CDR development

Formal Safety Assessment and RAM documentation activities will be dropped in the revised proposal. Details of the CDR structure and Parsons level of effort for documentation development were discussed at a pre-proposal meeting on February 3, 1993 at Parsons offices. The primary emphases of this revised CDR effort will focus in establishing a solid funding baseline for soil remediation at the FEMP. The CDR cost estimate should build upon the Enhanced Cost Study for Soil Remediation dated September 1992.

3. Guidelines

The FRD/CDR document shall be prepared in accordance with the guidelines outlines in the latest revision of the following documents:

a. Functional Requirements Document Guidelines, prepared by Parsons and dated January 1992 (Revision 0)

b. Conceptual Design Report Preparation Guide, prepared by Parsons and dated January 1992 (Revision 1)

4. Schedules

a.	50% CDR	All deliverable milestones to be negotiated
b.	100% CDR	following Parsons development of a Logic Path
c.	100% Cost Estimate	Schedule
d.	Approved CDR/Cost Est.	

Monthly status meetings shall be conducted to discuss the effort accomplished, problems and issues, and the plan for the next month's activities.

CPMPARATIVE SUMMARY OF CDR
SCOPE OF WORK

P.O. 81. Revision 0	P.O. 81. Revision 1
A. Safety Assessment documentation	A. Delete formal process from scope; however, outline any significant safety related issues which will need to be addressed in future engineering efforts and include in Section 6.0 of CDR.
B. Risk Assessment and Management documentation	B. Delete from scope
C. Evaluation of treatment alternatives	C. Include in Conceptual Design Report (CDR) - close integration with FERMCO Technology group, ORNL, and IT Corp. will be necessary. Confirm soil washing as BAT and integrate the current soil treatability studies at the FEMP into an optimized process as the CDR basis. Evaluate logistics of centralized or remote soil washing facilities.
D. Soil characterization and quantification	D. Include in CDR - soil characterization data is limited. Coordinate the research into available soil data with B. Hertel and R. Ninesteel of FERMCO. This will become a living document and will require incorporation data from the pilot system process.
E. Functional Requirements Document (FRD) (as per Revision 0 of FRD Guidelines dated January 1992)	E. Include the following FRD requirements into the CDR: 1) Functional Objectives Section with emphases on those areas dealing with environmental, material handling, process, and health & safety objectives. 2) Regulatory Requirements dealing specific with ARARs. (coordinate w/ARAR's document currently under development by ID Program)
F. Conceptual Design Report (as per Revision 1 of CDR Preparation Guideline dated January 1992)	F. Primary deliverable - should incorporate the elements outlined above for P.O. 81 Rev. 1 Scope of Work and the following sections related to CDR development:

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CPMPARATIVE SUMMARY OF CDR
SCOPE OF WORK

P.O. 81, Revision 0	P.O. 81, Revision 1
F. Conceptual Design Report (cont'd)	1.0 Project Description to include brief Introduction, Overview and Project Scope, Justification, and Leading Alternatives.
	2.0 Project Strategy and Schedule to include Functional Requirements (as outlined in Section E above) and address the issue of integrating construction sequencing and planning between the other CRU's with summary level schedules. An early "over-the-shoulder" review of this strategy will be required by FERMCO.
	3.0 Project Cost and Funding Strategy to include a cost estimate which builds upon the Enhanced Cost Study for Soil Remediation, developed in September 1992.
	4.0 Related Project Tasks, Schedules and Costs to outline possible engineering development studies for related issues which may need to be addressed in future engineering tasks having a potential impact to this project (ie., material handling and staging req's, disposition of related waste streams, integration req's, etc.)
	5.0 Quality Assurance to include summary level detail only.
	6.0 Safety, Environment, and Energy to include summary level data only.
	NOTE: Drawings and specifications required for this CDR effort should include: a site plan detailing the phasing/sequencing with the CRU's, plant layout of a proposed system for establishing a costing basis, P&ID's and PFD's as required. Equipment/component specification for the existing pilot system can be utilized for projecting costs on larger scale process.

ATTACHMENT B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Operational - Public Health and Environment	The total effective dose equivalent to members of the public is limited to 100 mrem in a year, exclusive of the disposal for radioactive material into sanitary sewage in accordance with 10 CFR 20.2003. The dose in unrestricted areas is limited to 2 mrem in 1 hour. 10 CFR 20.1301 [Relevant and Appropriate] Operations must be in accordance with the requirements of (proposed rule) 10 CFR 834 and DOE Order 5400.5 Chapter II involving DOE public dose limit for all exposure modes and all DOE sources of radiation. DOE Order 5400.5, Chapter II.1.a 10 CFR 834 (proposed rule, 58 FR 16268) [To Be Considered]	The treatment facility will be designed and operated to minimize the release of radionuclides. The radiological discharges will be estimated in order to qualitatively determine the impact of the facility upon off-site residents. Compliance will be demonstrated by site-wide environmental monitoring. Reports summarizing the site-wide monitoring results will be submitted to the US EPA annually.

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Operational - Soil Remediation (Uranium)	Using the computer code RESRAD and the guidance manual *A Manual for Implementing Residual Radioactive Material Guidelines* and ALARA principles, DOE and EPA determined acceptable limits for depleted uranium in soil. These limits are: 1) Average soil concentrations over any 10 meter by 10 meter area should not exceed 35 pCi of depleted uranium per gram of soil; and 2) 100 pCi/g should not be exceeded over any 1 square meter area. 10 CFR 834 (proposed rule preamble, 58 FR 16276) [To Be Considered]	The limits in 10 CFR 834 shall be implemented in the field during excavation activities. These limits have been used previously in the remediation of FUSRAP sites and were found to be acceptable. Compliance will be demonstrated by sampling for the comprehensive site-wide operable unit.
Operational - Soil Remediation (Radium-226 and 228)	The limits for radium-226 and radium-228 are less than 5 pCi/g in the first 15 cm of the surface layer and 15 pCi/g in any subsequent 15 cm layer. 40 CFR 192 [Applicable]	These limits will be implemented in the field during excavation activities. These limits have been used previously in the remediation of FUSRAP sites and were found to be acceptable. Compliance will be demonstrated by sampling for the comprehensive site-wide operable unit.

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Operational - Soil Remediation (Hazardous Waste)	Soil that contains listed hazardous waste or exhibits a hazardous waste characteristic will either be treated to remove the listed waste or eliminate the characteristic. This will be done under the "contained-in" policy (see discussion in the preamble of the proposed soil rule, 58 FR 48123). Hazardous wastes that remain in soil must be below the Universal Treatment Standards provided in proposed 40 CFR 268.48 Table UTS in order to be land disposed. Proposed 40 CFR 260.42, 268.40, and 268.48 [To-Be-Considered]	The soil washing/extraction process is not specifically designed to treat hazardous waste. Soil that has undergone uranium removal, but still contains hazardous waste, may require further treatment (not in project scope) prior to disposal. Process knowledge and appropriate analysis will be used to determine if the concentrated residue from treatment of mixed waste contaminated soil is also considered mixed waste, and whether it will be managed as such.
Operational - Soil Remediation (Petroleum)	Petroleum contaminated soil will be managed in accordance with OAC 1301:7. OAC 1301:7 [Applicable] Treatment standards for petroleum contaminated soil are as follows: benzene (0.006 ppm), toluene (4.0 ppm), ethylbenzene (6.0 ppm), xylene (28.0 ppm) and total petroleum hydrocarbons (40 ppm). Petroleum Contaminated Soil (Ohio EPA Guidance Policy PP-01-03-200, March 25, 1991) [To-Be-Considered]	Petroleum contaminated soil will be remediated to the levels provided by the Ohio EPA. Petroleum contamination above these levels will be excavated and packaged for disposal. Only soil below these limits will remain in situ.
Operational - Soil Remediation (Polychlorinated Biphenyls)	Polychlorinated Biphenyl (PCB) contaminated soil will be managed in accordance with 40 CFR 761. 40 CFR 761 [Applicable]	Current site procedures (e.g. Site-Wide CERCLA Quality Assurance Project Plan) require that soil containing greater than 2 ppm of PCBs must be excavated and packaged.

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Operational - Records	Record keeping must be performed according to DOE Order 5820.2A which specifies that records must be maintained from generation through final disposal. The specific data requirements are physical/chemical characteristics, quantity of radionuclides, waste volume, and other data necessary to demonstrate compliance with waste acceptance criteria. DOE Order 5820.2A Chapter III.3(m) [To Be Considered]	An operational record will be written and maintained until closure of the treatment facility. FEMP procedures for preparing and maintaining these operating records will be followed.
Operational - Security Fencing	A physical barrier (i.e., fence) and a 24-hour surveillance system must be provided to control the unknowing or unauthorized entry of persons or livestock onto the active portion of the remediation facilities. Signs (legible from a distance of 25 feet) must be posted at each entrance to the active portion and at other locations as required by 40 CFR 264.14(c). 40 CFR 264.14 {OAC 3745-54-14} [Relevant and Appropriate]	The fence and surveillance system currently at the FEMP are adequate to restrict access to the treatment facility. If the facility is located outside of the existing security zone, the zone will be extended to include the facility. Signs will be posted at each entrance to the active portion and at any other location required.

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Operational - Spill Prevention	Best Management Practices (BMP) programs shall be developed in accordance with good engineering practices and with the provisions of 40 CFR 125.104. The BMP program may reflect requirements for Spill Prevention Control and Countermeasure (SPCC), and may incorporate this plan by reference. The BMP shall address the requirements of 40 CFR 125.102 for any ancillary equipment. The owner or operator of a facility subject to this requirement shall amend the BMP whenever there is a change in facility design, construction, operation or maintenance which materially affects the facility's release potential. If BMP requirements are ineffective, the permit and/or BMP program shall be subject to modification to incorporate revised BMP requirements. 40 CFR 125.102 & 125.104 [Applicable] The secondary confinement structure shall be capable of retaining the maximum radioactive liquid waste inventory that may be released by a spill, leak, or overflow from the primary confinement structure. For outdoor application, the capacity must also include maximum predicted participation. The structure shall also be designed to preclude overtopping due to wave action. The capability for transferring collected liquids from secondary containment to an acceptable storage location shall be provided. DOE Order 6430.1A, Section 1323-5.1 [To-Be-Considered]	Any treatment facility's dikes/curbs will be designed to contain 100 percent of the volume of the largest tank within a common area, plus sufficient freeboard to allow for precipitation. Any collection sumps and liquid detection systems shall be provided as necessary. Inspection requirements for housecleaning, spillage, leaching, etc. are to be included as part of the Remedial Action Work Plan.

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ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Operational - Stormwater and Erosion Control	Industrial facilities (as defined in 40 CFR 122.26) are required to submit a NPDES Stormwater Discharge Permit Application to US EPA by October 2, 1992. This permit application is to identify the site-wide monitoring program (including monitoring parameters and locations) for all stormwater discharges. 40 CFR 122.26 [Applicable] The earthwork rules and regulations issued by the Hamilton County Department of Public Works state that temporary and/or permanent erosion and sediment control features and devices shall be designed and constructed in accordance with the State of Ohio Temporary Erosion Control Specifications. Hamilton County Earthwork Regulations [To Be Considered] Drainage control provisions of DOE Order 6430.1A are to be followed. DOE Order 6430.1A [To Be Considered]	Stormwater from this facility will be managed by the FEMP Stormwater Treatment System (e.g., collection in stormwater retention basins prior to treatment at the Advanced Wastewater Treatment [AWWT] facility). Soil erosion controls will be provided as necessary.

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Operational - Worker Protection	The occupational radiation doses specified in 10 CFR 20 Subpart C shall be followed. In addition, the radiation survey and monitoring requirements, the administrative controls for restricted areas, and other precautionary procedures identified in 10 CFR 20, Subparts D to J shall be followed. Although the radiation protection standards promulgated under 10 CFR 20 are only applicable to NRC licensed facilities, these protection standards are deemed to be relevant and appropriate for individuals entering a radiologically controlled area at the FEMP. These standards are mandatory after January 1, 1994 with early compliance encouraged. 10 CFR 20 Subparts C to J [Relevant and Appropriate] At DOE facilities, the radiation protection standards contained in DOE Order 5480.11 for occupational workers, unborn children, minors, and on-site members of the public shall not be exceeded. DOE Order 5480.11 [To Be Considered] Draft proposed 10 CFR 835 [To Be Considered]	The existing FEMP radiation protection program is being implemented under DOE Order 5480.11. The FERMCO Environmental Safety and Health manual only identifies DOE requirements and DOE Radiation Control manual. This program is consistent with the requirements of 10 CFR 20 Subpart C. Occupational workers and on-site members of the public shall be required to wear dosimeters and personal protective equipment (PPE) when entering a radiologically controlled area. Radiation monitoring shall also be required for all individuals exiting a radiologically controlled area. Details regarding the PPE and radiation monitoring requirements will be identified in the task-specific health and safety plan developed for the Remedial Action Work Plan and based on actual operational experience.

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ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Siting - Floodplains and Wetlands	Federal agencies are to avoid construction within a floodplain or wetland unless there are no practicable alternatives. If it is necessary to locate the facility within a floodplain or wetland, all practicable measures are to be taken to minimize any impacts to the floodplain or wetland. A floodplain or wetland assessment must be published in the Federal Register prior to taking any action within the floodplain/wetland to allow time for public review and comment. 10 CFR 1022 [Applicable] Executive Orders 11988 & 11990 [To Be Considered]	The treatment facility will be located in neither an 100-year floodplain nor a wetland.
Siting - Endangered Species	The remedial action shall mitigate any adverse impact which may affect the continued existence of any endangered species or threatened species. The remedial action shall also not result in the destruction or adverse modification of a critical habitat. Endangered Species Act of 1978 (16 USC 1531) [Applicable] Ohio Endangered Species Act for Plants and Animals (ORC 1518, OAC 1501:18-1-01, ORC 1513.25) [Applicable]	There are no federally listed threatened or endangered species at the FEMP or its immediate vicinity. Therefore, neither notification nor mitigative measures are required for this remedial action.

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Siting - Historic Sites	The Secretary of the Interior must be notified in writing whenever DOE finds or is notified in writing by an appropriate historical or archaeological authority that the activities in connection with a project may cause irreparable loss or destruction of significant scientific, prehistorical, historical, or archaeological data. Any data that may be lost or destroyed must be preserved by the DOE or Department of the Interior. National Historic Preservation Act, 16 USC 470 Archeological and Historic Preservation Act, 16 USC 469a-1 Archeological Resources Protection Act, 16 USC 470 [Applicable]	There are no known sites of archaeological significance at the FEMP. Therefore, neither notification nor mitigative measures are required for this remedial action. Should a site be discovered, the DOE will notify the Department of the Interior and then the appropriate course of action will be identified.
Siting - US Fish and Wildlife Coordination Act	Adverse impacts of activities associated with the destruction or loss of wetlands are to be avoided where practicable alternatives exist. After consultation with the US Fish and Wildlife Service and the appropriate State agency, necessary actions to protect fish and wildlife from impacts associated with modifying streams or areas affecting streams are to be implemented. Fish and Wildlife Coordination Act (16 USC 661 et seq) [Applicable]	On-site location and operation of a soil treatment facility may impact Paddy's Run and adjacent wetlands areas. Such action should be coordinated with State and Federal wildlife agencies to ensure preservation of wetlands and aquatic biota and wildlife.
Treatment Systems - Corrosion Evaluation	A corrosion evaluation shall be performed for tank systems or components in which the external shell of a metal tank or any external metal component will be in contact with the soil or with water. The corrosion evaluation will include those items listed in 40 CFR 264.192(a)(3). 40 CFR 264.192(a)(3) {OAC 3745-55-92} [Applicable]	A corrosion evaluation will be conducted as part of the design/selection of any metal tanks and/or tank components. Any corrosion protection requirements will be specified on the design drawings and specifications. The corrosion protection requirements, if any, will be summarized in the required tank assessment report.

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ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Treatment Systems - Foundations	Tank systems will be designed to ensure the foundations support the load of a full tank, tanks are anchored to prevent flotation, and withstand frost heave. 40 CFR 264.192(a)(5) {OAC 3745-55-92} [Applicable]	Any required tank systems will be designed to withstand these conditions. Design calculations will be prepared during Title I/II. The foundation support information will be summarized in the required tank assessment report.
Treatment Systems - Secondary Containment	Secondary containment systems (including leak detection and removal systems) must be provided for each tank and ancillary equipment to prevent release of any hazardous waste to the environment in the event of a spill or leak. The specific design requirements are identified in 40 CFR 264.192. 40 CFR 264.193 {OAC 3745-55-93} [Applicable]	Design details for any secondary containment system will be developed in conjunction with the tank design during Title I/II.
Treatment System - Ancillary Equipment	Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion, or contraction. 40 CFR 264.192(e) {OAC 3745-55-92} [Applicable]	The appropriate support and protection of any ancillary equipment will be specified on the design drawing and specifications.

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Treatment System - Backfill Material	Underground tank systems (including underground pipes) shall be protected against adverse effects of vehicular traffic by either design or operational measures. 40 CFR 264.192(a)(4) {OAC 3745-55-92} [Applicable] Underground tanks and components must be backfilled with a non-corrosive, porous, homogeneous substance. The backfill material must be placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported. 40 CFR 264.192(c) {OAC 3745-55-92} [Applicable]	If any of the tank systems or groundwater transfer piping is placed underground, the backfill materials will be specified on the design drawings and specifications.
Treatment System - Spill Prevention	Tank systems are to be equipped with spill prevention devices (i.e., check valves, dry disconnect couplings) and overfill controls (i.e., liquid level probes, high level alarms, interlocks to stop flow, or a bypass system to a standby tank). For open top tanks, sufficient freeboard shall be maintained to prevent overtopping by wave or wind action or by precipitation. 40 CFR 264.194 {OAC 3745-55-94} [Applicable]	The appropriate mechanical and instrument controls will be specified on the design drawings and specifications.

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ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Treatment System - Tank Installation	The installation of the tank system is to be inspected by an independent, qualified installation inspector or an independent, qualified registered professional engineer for structural damage or inadequate construction/installation (i.e., weld breaks, punctures, scrapes of protective coatings, cracks, and corrosion). The installation of any required corrosion protective system that is field fabricated must be supervised by an independent corrosion expert. The tank and ancillary equipment must be leak tested prior to being covered, enclosed or placed into service. 40 CFR 264.192(b), 264.192(d) & 264.192(f) {OAC 3745-55-92} [Applicable] An installation report will be required to be prepared by the inspector/engineer. Any required repairs and field fabrication of a corrosion protection system will be documented in the installation report. 40 CFR 264.192(a) {OAC 3745-55-92} [Applicable]	This requirement will be incorporated into the specification for any tank installation. An installation report will be prepared by the inspector/engineer. Any required repairs and field fabrication of a corrosion protection system will be documented in the installation report. The installation report will be certified in accordance with 40 CFR 270.11(d).

ATTACHMENT B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE DOCUMENTS

CATEGORY	REGULATORY REQUIREMENT	IMPLEMENTATION STRATEGY
Treatment System - Wastewater Discharges	Any wastewater discharge from the facility to a surface water body must comply with all the requirements of the NPDES program, including monitoring and record keeping. Also applicable are the technology-based effluent limitations and standards based under Section 301 of the Clean Water Act (CWA) and technology-based controls for toxic pollutants. 40 CFR 122.41, 40 CFR 122.44 {OAC 3745-33-04 & 05} [Applicable] The design must ensure that the construction/operation of the facility does not violate the minimum water quality requirements for the Great Miami River or for the Ohio River. The facility shall not be a source of floating debris, materials producing odor, and/or color change, and substances in toxic concentrations. The specific water use designation for the Great Miami River and Paddy's Run is identified in OAC 3745-1-21. The corresponding water quality criteria is listed in OAC 3745-1-07. "Mixing Zones" may be established for each discharge pursuant to OAC 3745-1-06. OAC 3745-1-06, OAC 3745-1-07, OAC 3745-1-21, & OAC 3745-1-32 Table 32-1 [Applicable] The annual average radionuclide concentrations in wastewater effluents are to be controlled so that the levels specified in Appendix B, Table II of 10 CFR 20 (Sections 20.1001 to 20.2401) are not exceeded. 10 CFR 20.1302(b) [Relevant and Appropriate]	Wastewater from the soil treatment facility will be sent to the AWWT for treatment prior to reuse or discharge. The design of this portion (as well as other portions) of the AWWT is not in the scope of this project.

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ATTACHMENT C

SOIL CHARACTERIZATION AND QUANTIFICATION STUDY

6376

Soil Characterization and Quantification Study

Operable Unit 5
Project Order 81
November 1993
Revision D

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio
FERMCO Subcontract No. 2-21487

PARSONS

Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

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Soil Characterization and Quantification Study

Operable Unit 5
Project Order 81
November 1993
Revision D

Environmental Remedial Action Project
Fernald Environmental Management Project
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6376

Soil Characterization and Quantification Study

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LIST OF ACRONYMS AND ABBREVIATIONS

COC	Constituent of Concern
CSV	Contaminated Soil Volume
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
GWMG	Ground Water Modeling Grid
mg/kg	milligrams per kilogram
OU	Operable Unit
pCi/g	picoCuries per gram
ppm	parts per million
PRG	Preliminary Remediation Goal
RI/FS	Remedial Investigation/Feasibility Study
U-total	Total Uranium

SECTION 1

INTRODUCTION

PARSONS was tasked under Project Order 81 to perform a Soil Characterization and Quantification Study to support the conceptual design of a soil remediation system for Operable Unit 5 (OU-5) (PARSONS 1993a). The Soil Characterization and Quantification Study is intended to develop a preliminary estimate of the distribution of contaminants in soil over the FEMP site, to provide a preliminary estimate of the in situ contaminated soil volumes which will require remediation, and to provide a preliminary estimate of the in situ soil volumes which will require excavation. Concentration contour maps showing the estimated locations and magnitudes of contamination in the Fernald Environmental Management Project (FEMP) surface soils were created. These maps provide the basis for a preliminary estimate of the soil volumes requiring remediation. The source of information for this study was the data base developed as a result of the FEMP Remedial Investigation/Feasibility Study (RI/FS) soil sampling program. This report documents the procedure used to prepare the concentration contour maps and summarizes the results of the estimated contaminated soil volume calculations.

Four soil contaminants were chosen as Constituents of Concern (COCs) for these calculations: Thorium-230, Thorium-232, Uranium-238, and total Uranium (U-total). Action levels for the COCs were assumed from preliminary remediation goals developed in the *Sitewide Characterization Report (DOE 1993).* Contaminated Soil Volume (CSV) estimates were calculated based on these assumed action levels. CSV estimates were made at four depth intervals (0-2 feet, 2-5 feet, 5-10 feet, and 10-20 feet below land surface) by multiplying the area where estimated concentrations exceeded the action level by the thickness of the interval.

SECTION 2

SOURCE DATA AND METHODOLOGY

The primary source of information for this study was a Fernald Environmental Restoration Management Corporation (FERMCO) data base containing results of chemical analysis of subsurface soil samples collected during the installation of on-site RI/FS monitoring wells. A typical data base record contains the following information: number or name of well, Ohio State Plane Coordinates (NAD 27) of well, date, name of compound or element, top and bottom depth of the sample interval, concentration, units of measurement, and some auxiliary information about type and precision of measurements.

The following steps were undertaken to prepare concentration contour maps and estimate the CSVs:

1) Extract data relevant to the particular COC from the data base
2) Sort data by depths and types of measurements
3) Spatially interpolate data onto the nodes of a regular grid with a given origin and orientation
4) Calculate the total volume of cells with a concentration higher than an action level
5) Draw concentration contour maps of the distribution of contaminants over the site

Data management was performed with the help of the dBASE-IV software package and a FORTRAN-77 code which was developed for the sorting and primary statistical analysis. Spatial interpolation was conducted using the "Kriging" gridding method of the GRID program from the SURFER software package. Concentration contour maps were also prepared using SURFER. Selected results were stored in a special three-dimensional grid file and transferred to the INTERGRAPH CAD system for plotting.

The following depth intervals, or layers, were chosen for the calculations: 0-2 feet, 2-5 feet, 5-10 feet, and 10-20 feet. The Groundwater Modeling Grid (GWMG) (PARSONS 1993b) was the basis for a grid created to perform the calculations. The results are represented in the nodes of the grid with the following parameters:

1) The origin of the grid coordinate system is located at a point with the Ohio State Plane Coordinates (NAD27) x_0=1,379,948.67 feet (east), y_0=469,197.59 feet (north).

2) The X and Y axes of the grid are rotated 30 degrees counter-clockwise relative to the Ohio State Plane Coordinate axes.

3) The size of the grid cells are 125 feet by 125 feet.

4) The grid used for these calculations was expanded from 78 rows and 102 columns used in the GWMG to 102 rows and 102 columns.

Figure 2-1 presents the grid used for these calculations and shows the relationship of the grid to the FEMP boundaries and the Ohio State Plane Coordinates.

Approximately 100 potential COCs have been identified for the soil at the FEMP in Table 2-3 of Part III of the *Sitewide Characterization Report* (DOE 1993) (see Attachment A). Four soil contaminants were chosen for these calculations based on their prevalence in FEMP soil: Thorium-230, Thorium-232, Uranium-238, and total uranium.

An action level must be selected to estimate the CSV for each COC. Currently, only U-total has a proposed risk-based action level of 35 picoCuries per gram (pCi/g) (proposed rule 10 CFR 834 [58 FR 16268]). Assuming that soil is primarily contaminated with depleted uranium, 35 pCi/g is equivalent to 76 parts per million (ppm). This value was determined using isotopic distributions for depleted uranium (from the proposed rule for 10 CFR 834 [58 FR 16268]) and formulae from *The Health Physics and Radiological Health Handbook* (Shleien 1992).

Action levels were assumed for the other COCs. The Preliminary Remediation Goals (PRGs) for recreational land use scenarios from the *Sitewide Characterization Report* (DOE 1993) (see Attachment A) were chosen as action levels for calculating CSVs. The volume of soil with contaminant concentration levels above the respective action level was calculated for each COC. Table 2-1 lists the name, unit of measure, action levels, and the number of measurements available per layer for each of the four COCs evaluated.

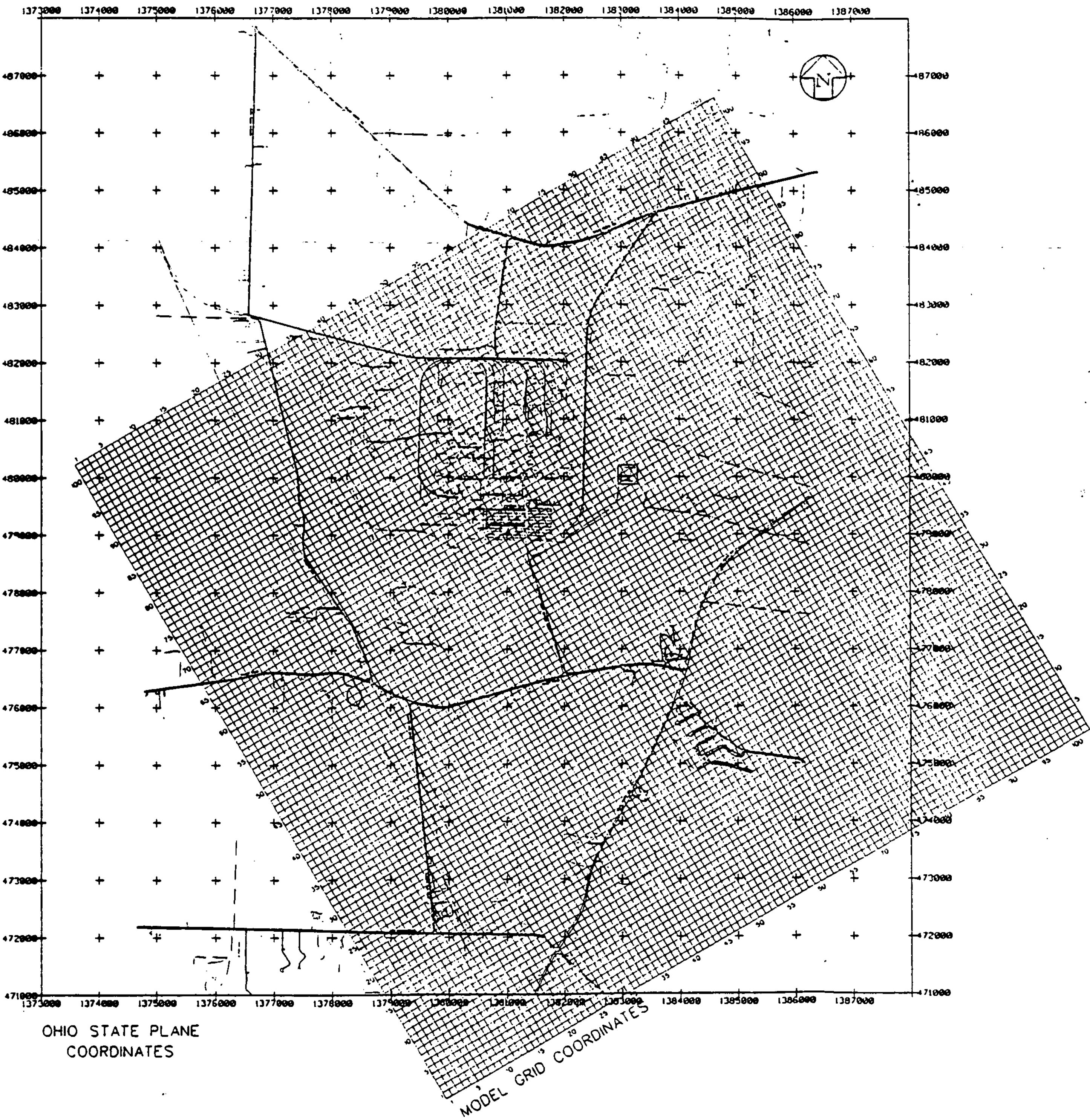

Figure 2-1 - Location Map Showing Model Grid and Site Features

Table 2-1 - COCs, Action Levels, and Numbers of Measurements per Layer

COC	Units	Action Level	Numbers of Measurements in Layers			
			0-2 Feet	2-5 Feet	5-10 Feet	10-20 Feet
Thorium-230	pCi/g	1,520	410	155	154	177
Thorium-232	pCi/g	305	410	155	153	177
Uranium-238	pCi/g	527	401	141	142	174
Uranium-Total	pCi/g	35	652	281	211	359

SECTION 3

DETAILS OF THE STATISTICAL PROCEDURE

The substantial part of the statistical analysis of the soil contamination is the spatial interpolation of data from random "XYZ" form to the regular "GRID" form. It is widely recognized that the Kriging method is an effective and natural approach in the geophysical and environmental data analyses (Journel 1989). Kriging is a linear regression method where the estimated value at some unsampled point $\vec{r}_O$ (nodes of the grid in this case) is sought in the form of a linear combination of measured values in the N nearest "sampled" points $\vec{r}_i$:

$$\tilde{Z}(\vec{r}_0) = \sum_{i=1}^{N} \lambda_i Z(\vec{r}_i) \qquad \text{Equation 1}$$

The coefficients, λ, are calculated from the least square conditions

$$[Z(\vec{r}_0) - \sum_{i=1}^{N} \lambda_i Z(\vec{r}_i)]^2 = \min(\lambda_i \ldots, \lambda_n) \qquad \text{Equation 2}$$

Minimization gives the linear system of "normal" equations for the unknown coefficients

$$\sum_{i=1}^{N} \lambda_i C(\vec{r}_i, \vec{r}_j) = C(\vec{r}_i - \vec{r}_0) \qquad \text{Equation 3}$$

The matrix $C(r_i, r_j)$ is a matrix of covariances between the concentrations in points $\vec{r}_i$ and $\vec{r}_j$.

Kriging provides the best unbiased estimates (i.e., give the minimum variance of errors) when applied to Gaussian random fields. If the random field is not Gaussian, then the estimates (Equations 1-3) continue to be the best, but they are no longer unbiased. This important fact is a substantial limitation when applying Kriging to the problems of chemical contamination. The field of chemical concentrations is positive. However, the structure of the linear system (Equation 2) does not guarantee that the solution will be positive. This means that direct application of Kriging can provide incorrect results which are negative and have a probability of occurrence greater than zero.

A more sophisticated approach could be applied to overcome this difficulty. This approach, referred to as the "disjunctive Kriging" approach, is based on the idea of searching for a non-linear transformation of the original field so as to make it Gaussian. The solution of the linear equation (Equation 3) is calculated after this non-linear transformation is performed. The disjunctive Kriging approach is cumbersome, has its own statistical restrictions, and has limited accuracy.

Logarithmic transformation of the original field is a more simple and practical approach. Three reasons make this transformation appropriate. The first reason has a statistical root. It is recognized that the fields of contaminants often are subject to a log-normal distribution. This means that after the logarithmic transformation, the resulting field will have a form close to the Gaussian one and, consequently, better conditions for applying the Kriging method. The second reason is that the logarithmic transformation automatically excludes the negative solutions for the interpolated values. Finally, the logarithmic scale is more suitable for graphical representations of fields with a very wide range of variation.

All methods of contouring populations of sparse data have limitations. In this case, the field of contamination is assumed to be continuous and smooth, and all points of this field are assumed to be statistically equivalent. Only under these constraints does the concept of "contour" or "isoline" gain definite meaning. Obviously, these notions have restricted applicability in the case of the FEMP site (as well as any other site). Here the "ordinary soil" domains have sharp borders with very high concentration domains like waste pits and with the zero concentration domains like building foundations. Obviously, these closed domains cannot be characterized in the same terms as "ordinary soil" and should be excluded from consideration. The isolines (or "contours") which happen to pass through these domains cannot be interpreted literally. To perform this analysis, data from borings inside the OU-1 waste pits were excluded because samples from these locations are samples of waste, not contaminated soil. Analyses included in these calculations were from samples in soil only. In other respects, the field of contamination was assumed to be statistically uniform and isotropic. Information about contamination changes over time and possible transport mechanisms were not used, except for those clearly evident.

All methods of quantification based on the spatial interpolation are highly approximate. Nevertheless, these methods are useful for the overall screening and rough quantification of contaminated areas. These methods have been applied to the FEMP site, and preliminary estimates of CSVs have been produced.

SECTION 4

VOLUME ESTIMATES

4.1 Estimate of Contaminated Soil Volumes

CSVs were estimated based on the recreational use action levels presented in Table 2-1. Each cell of the grid where the concentration was higher than the prescribed action level was considered "contaminated." The cells with concentrations lower than the action level were considered "clean."

Initial CSV estimates were made using the model grid and a single 20-foot-thick layer. The estimated contamination distribution for U-total with an action level of 35 pCi/g was calculated using the methods described in Sections 2 and 3. The estimated contaminated area was contoured using SURFER, and the estimated CSV was calculated by multiplying the area by 20 feet. The CSV calculated using this method was approximately 1.25 million cubic yards. Figure 4-1 shows the estimated U-total distribution and Table 4-1 lists the area and volume of the individual stippled areas shown in Figure 4-1. These areas were calculated using the INTEGRAPH area functions. The estimated CSV (area by 20 feet) is about 1.33 million cubic yards or about 106 percent of the CSV estimated using the SURFER-based procedure. The volumes are similar given the size of the areas, and the difference is probably due to differences in area interpolation between the two software packages.

Table 4-1 - Areas and Volumes of U-Total Contaminated Soil in the 0-20 Feet Layer

Subarea No.	Area (square feet)	Volume (cubic yards)
1	391,000	289,630
2	23,653	17,521
3	36,418	26,976
4	102,919	76,236
5	484,697	359,035
6	249,688	184,954
7	162,174	120,129
8	337,641	250,104
Totals	1,788,190	1,324,585

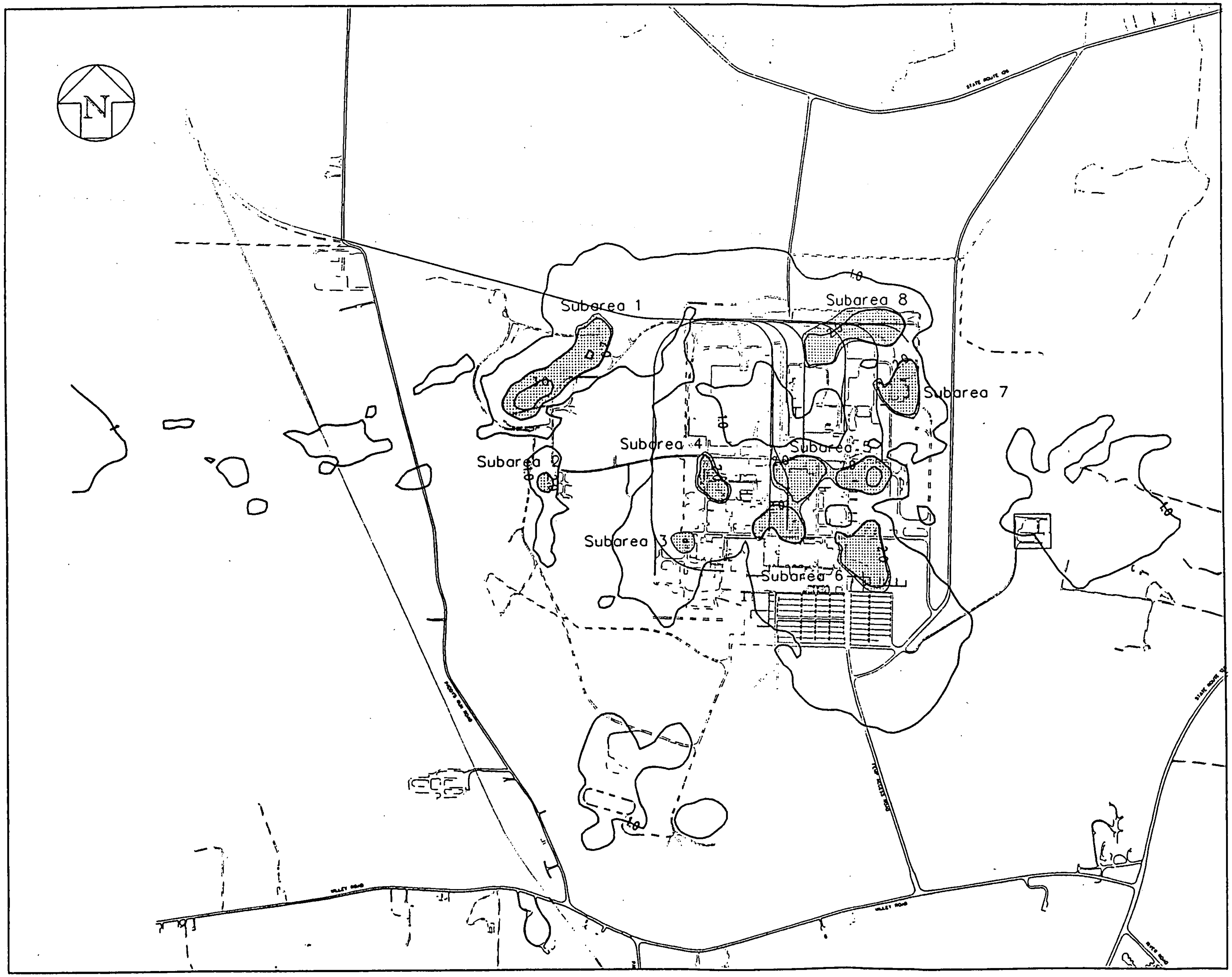

Figure 4-1 Distribution of U-Total in Soil 0-20 Feet Below Land Surface

/usr/era/ou5/po81/erma/po81/
dgn/map/hor/dpth/skx02424.dgn

Figure 4-1 - Distribution of U-Total in Site Soils 0-20 Feet Below Land Surface

FERMCO requested refinements in this estimate, and subsequent CSV estimates were made using multiple layers in the model grid. The following layers were chosen for the revised estimates: 0-2 feet, 2-5 feet, 5-10 feet, and 10-20 feet. Estimated concentration distributions were calculated for four COCs (U-total, U-238, Th-228, and Th-230) and plotted using SURFER. CSVs were calculated using areas from the SURFER plot times layer thickness.

The results of the revised CSV estimation for U-total and U-238 are given in Tables 4-2 and 4-3. Similar tables for Th-228 and Th-230 were prepared but are not presented because the typical concentrations of these contaminants are lower than the action level (Table 2-1) and the CSVs calculated are equal to zero.

Table 4-2 - CSV Estimates for U-Total by Operable Unit and Layer

Operable Unit	Area (Acres)	CSV in Layers (thousand cubic yards)				
		0-2 ft	2-5 ft	5-10 ft	10-20 ft	Total
1	42.3	13	83	32	0	128
2	29.8	4	9	15	0	28
3	156.8	203	52	86	87	428
4	5.6	0	0	0	0	0
5	1275.2	6	10	4	0	20
Total	1509.7	226	154	137	87	604

The CSV estimates are strongly dependent on the action level chosen. A series of sensitivity calculations was performed to demonstrate this dependence. Tables 4-3 and 4-4 show the CSVs in layers versus differing action levels for U-total and U-238 respectively. These calculations were performed for the entire area covered by the grid. The sensitivity analysis cannot be performed for each OU separately due to strong fluctuations of estimates for small areas. The last column of Table 4-4 shows the CSV for U-238 for the action level shown in Table 2-1 (527 pCi/g). The CSVs for this action level are zero in all layers.

Table 4-3 - CSVs Versus Action Level for U-Total (million cubic yards)

	Action Level ppm									
Layer	**0.1**	**1.0**	**10**	**30**	**50**	**70**	**76**	**82**	**90**	**120**
0-2 ft	12.30	12.20	2.48	0.51	0.34	0.25	0.23	0.20	0.18	0.10
2-5 ft	18.40	18.40	3.05	0.44	0.23	0.16	0.16	0.14	0.13	0.09
5-10 ft	30.70	30.60	2.81	0.56	0.29	0.16	0.17	0.10	0.09	0.05
10-20 ft	61.40	57.50	1.74	0.28	0.18	0.10	0.09	0.08	0.06	0.02
Total 0-20 ft	1220.8	118.70	10.08	1.79	1.04	0.67	0.65	0.52	0.46	0.26

Table 4-4 - CSVs Versus Action Level for U-238 (million cubic yards)

	Action Level pCi/g									
Layer	**0.1**	**1**	**10**	**30**	**50**	**60**	**70**	**120**	**300**	**527**
0-2 ft	12.30	9.00	0.91	0.38	0.20	0.16	0.12	0.04	0.01	0.00
2-5 ft	18.40	9.30	0.67	0.23	0.13	0.09	0.06	0.03	0.01	0.00
5-10 ft	30.70	17.20	3.57	1.13	0.57	0.44	0.35	0.14	0.02	0.00
10-20 ft	61.40	24.50	0.63	0.30	0.16	0.12	0.09	0.02	0.00	0.00
Total 0-20 ft	122.80	60.00	5.78	2.04	1.06	0.81	0.62	0.23	0.04	0.00

Figure 4-2 is a transparent overlay for use with other figures in this report. Figure 4-2 shows selected site physical features plus selected OU boundaries used for these calculations.

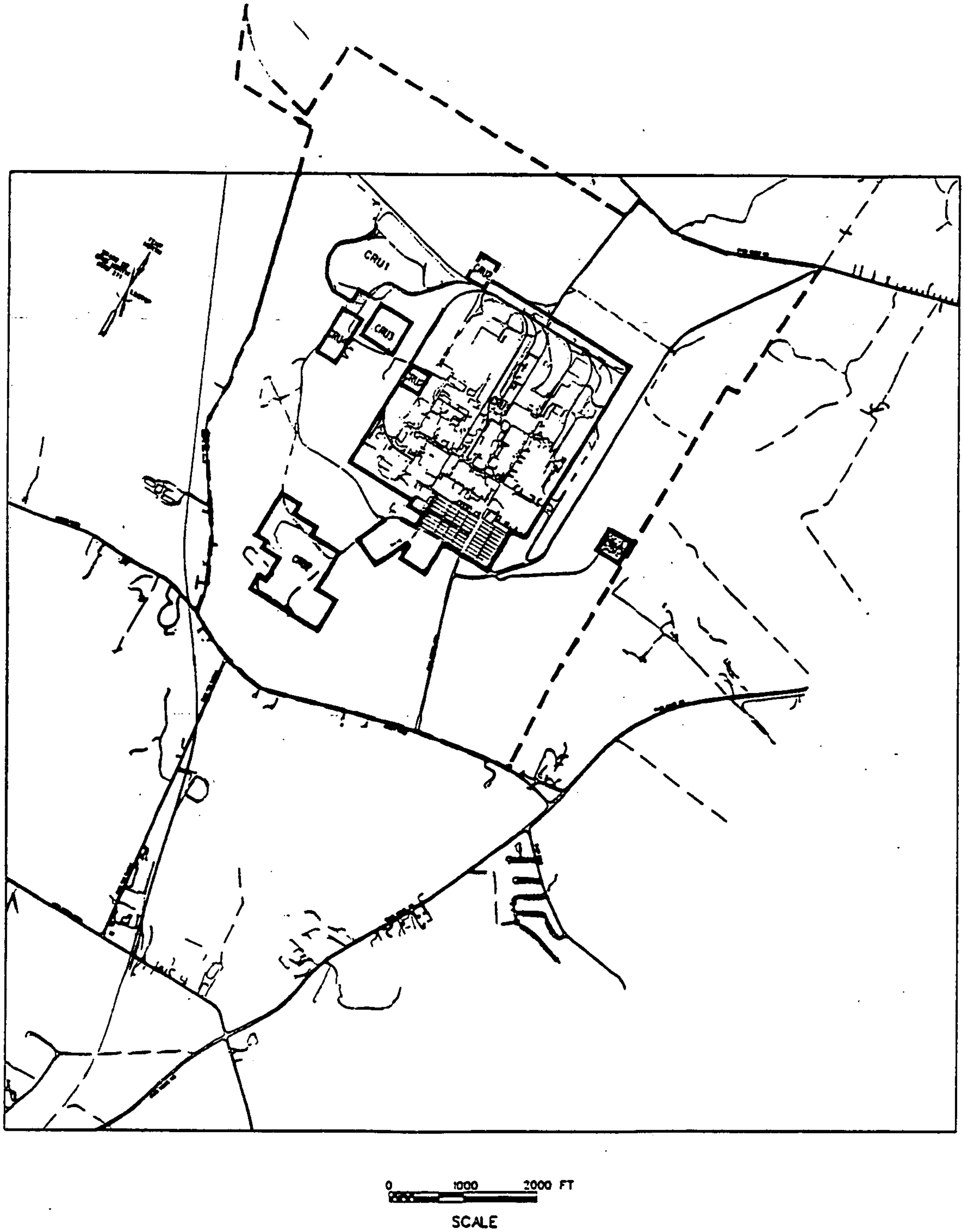

Figure 4-2 - Transparent Overlay Showing Site Features

Data points are indicated by triangles in figures throughout this report. Due to a limited number of data points in each layer, further subdivision of the total volume of the site into small layers can lead to big fluctuations in CSV estimates. An example of such a behavior is seen in Figures 4-3 through 4-6. Figures 4-3 and 4-4 give the distribution of U-238 (logarithms of concentrations in pCi/g, local grid coordinates) in the 0-1 feet layer and the 1-2 feet layer, respectively. Figures 4-5 and 4-6 give the same distributions in orthographic projections. Abnormally high concentrations are seen in the right upper corner of the grid in the 1-2 feet layer (Figure 4-4). This is a result of Kriging extrapolation of high concentrations from the area of OU-3 where a high density of data points and high concentration of contaminants exist. However, by plotting the distribution for the 0-2 feet layer, the extrapolated concentrations tend to zero as the distance from OU-3 increases because there are enough supporting measurements of low concentration in the right upper corner of the grid in the 0-2 feet layer. The contour map and orthographic projection of distribution for the 0-2 feet layer are shown in Figures 4-7 and 4-8, respectively.

The CSVs were estimated separately for each OU. The area bounded by the defined grid and outside the boundaries of OU-1 through OU-4 was considered to be OU-5. However, this definition of OU-5 was believed to overestimate the CSV as a result of extrapolating concentrations to locations with little or no data points. Thus, the outer boundary of OU-5 for the calculations was selected in such a way as to be well represented by the measurement points. Figure 4-2 showed the OU boundaries used for the calculations..

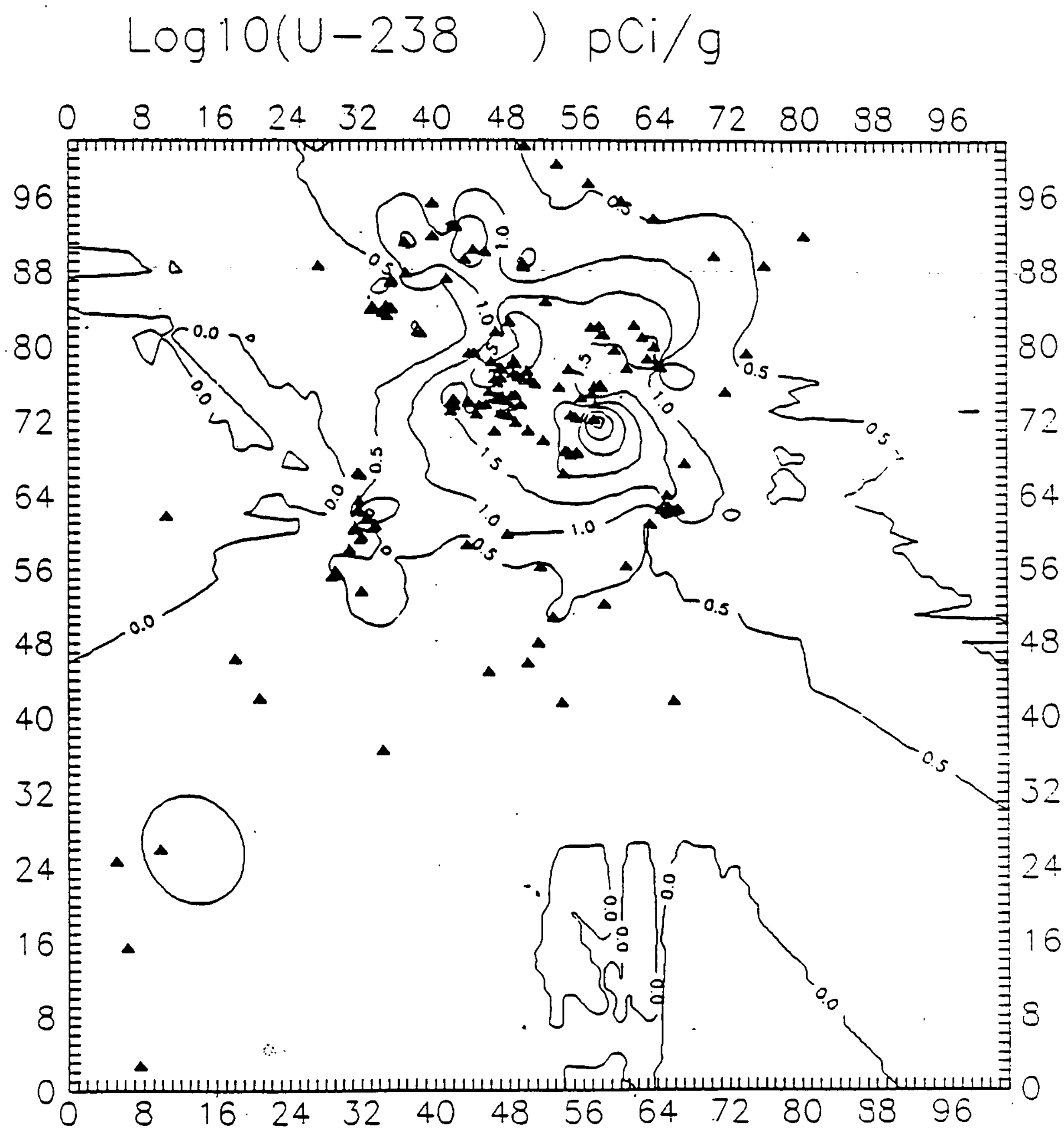

Figure 4-3 - Distribution of U-238 in Site Soils for the Layer 0-1 Feet

Log10(U-238) pCi/g

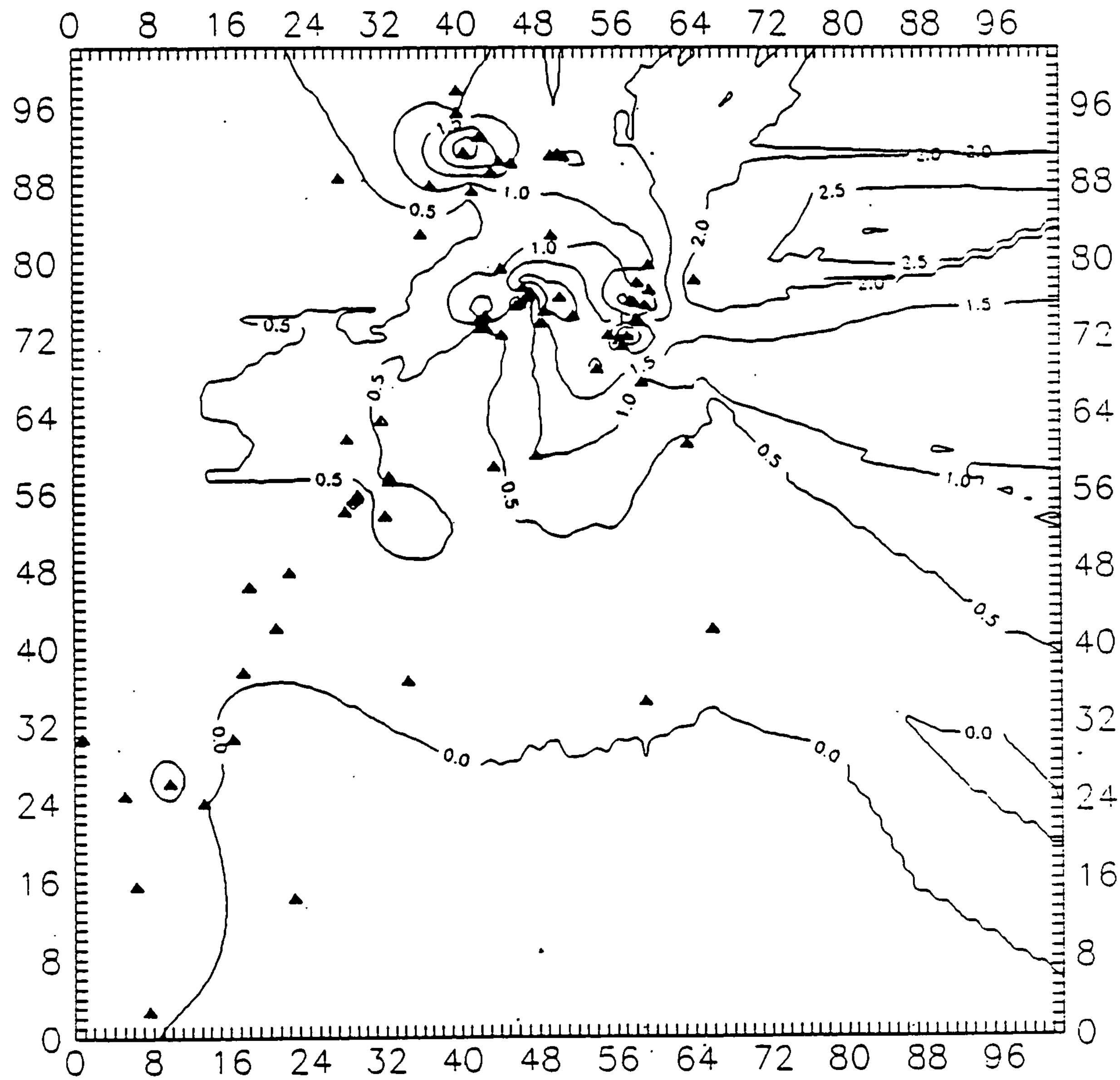

Figure 4-4 - Distribution of U-238 in Site Soils for the Layer 1-2 Feet

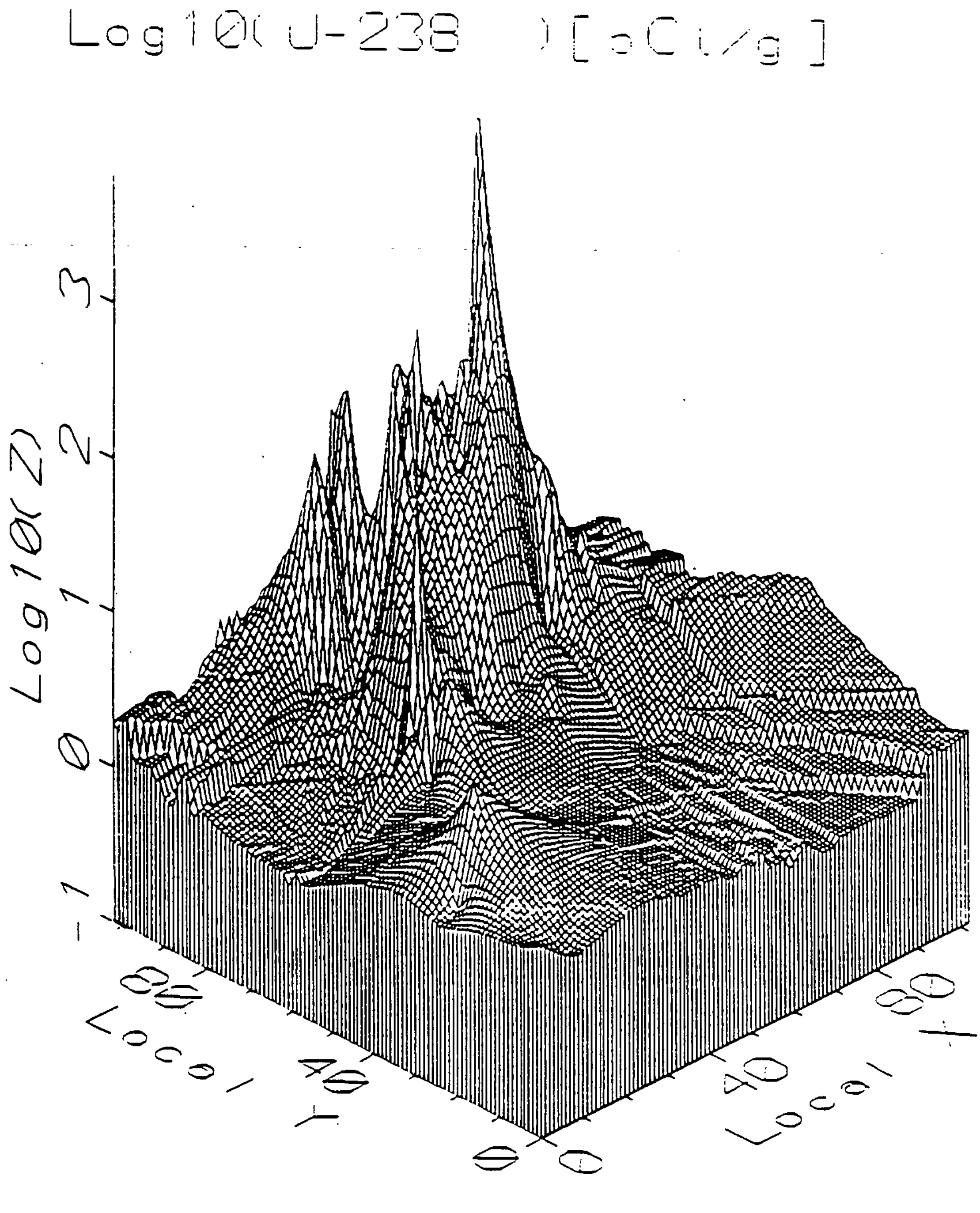

Figure 4-5 - Distribution of U-238 in Site Soils for the Layer 0-1 Feet (Orthographic Projection)

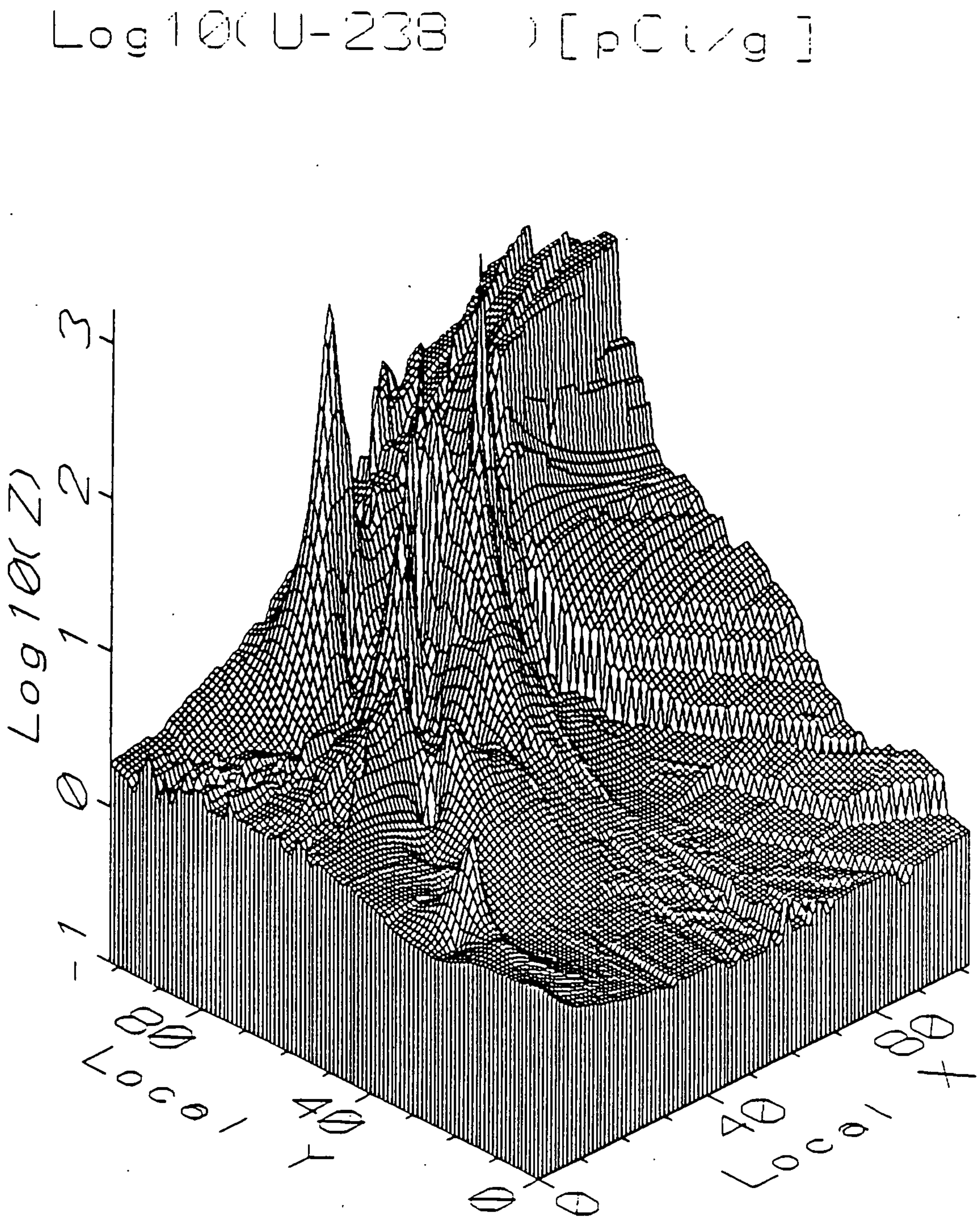

Figure 4-6 - Distribution of U-238 in Site Soils for the Layer 1-2 Feet (Orthographic Projection)

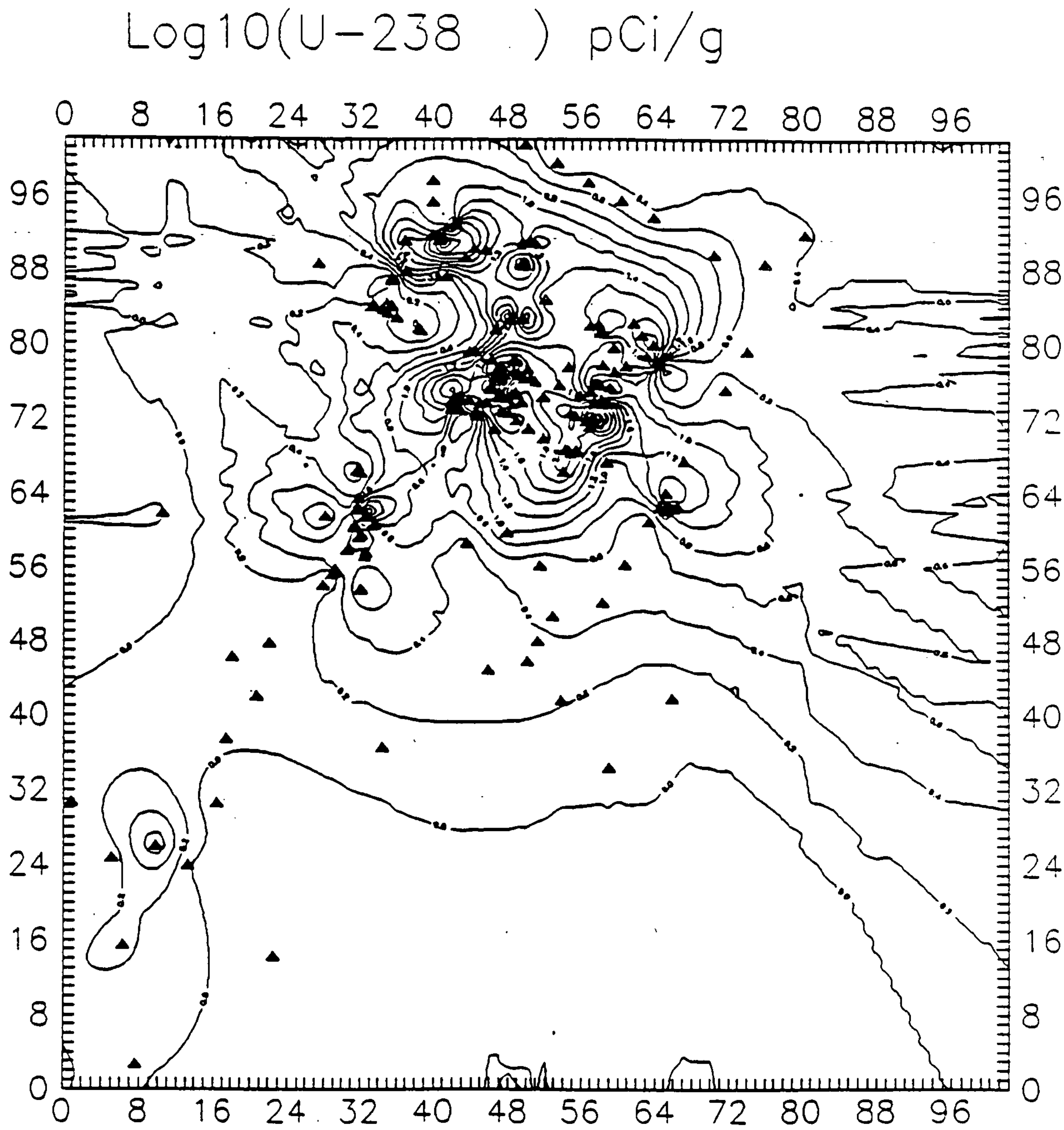

Figure 4-7 - Distribution of U-238 in Site Soils for the Layer 0-2 Feet

Log10(U-238) [pCi/g]

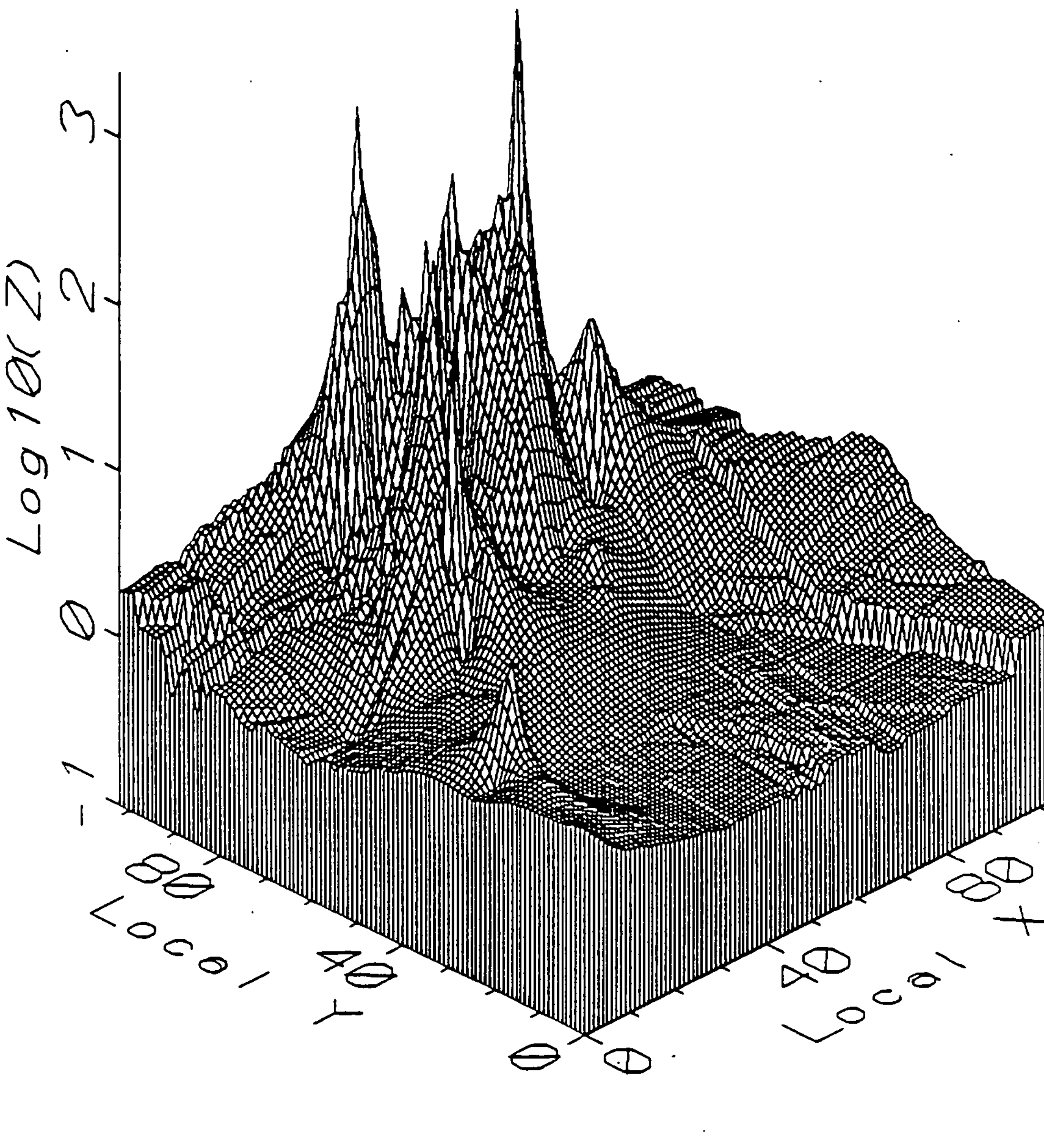

Figure 4-8 - Distribution of U-238 in Site Soils for the Layer 0-2 Feet (Orthographic Projection)

4.2 Estimate of Excavated Soil Volumes

While Table 4-2 presented the estimated CSVs for each OU, substantially more soil volumes must be excavated in order to uncover contaminated soils in deeper layers. Table 4-5 is a preliminary estimate of soil volumes which may require excavation. Table 4-5 is based on the results presented in Table 4-2 and an assumption that soils above contaminated soil to be excavated must also be removed. Therefore, the estimated soil volume in each layer may not be less than the volume in any lower layer. Additional excavation for slope stability may be required. If an additional 10 percent of the excavated volume is allowed for slope stability excavation, the volume of soil which may require excavation is estimated to be approximately 800,000 cubic yards.

Table 4-5 - Estimated Soil Volumes Requiring Excavation

	Volume in Layers (Thousand Cubic Yards)				
Operable Unit	**0-2 feet**	**2-5 feet**	**5-10 feet**	**10-20 feet**	**Total**
1	83	83	32	0	198
2	15	15	15	0	45
3	203	87	87	87	464
4	0	0	0	0	0
5	10	10	4	0	24
Total	311	195	138	87	731

SECTION 5

GRAPHICAL PRESENTATION OF RESULTS

The CSV estimates presented in Section 4 were based on contour maps showing the distribution of contaminants over the FEMP site. Figures 5-1 through 5-4 show the estimated concentrations of U-total at depths of 0-2 feet, 2-5 feet, 5-10 feet, and 10-20 feet. Figures 5-5 through 5-8, 5-9 through 5-12, and 5-13 through 5-16 show the corresponding concentrations at depth for U-238, Th-230, and Th-232, respectively. Figures 5-1 through 5-16 may be used with the transparent overlay (Figure 4-2) to identify the approximate location of data points relevant to the site physical features. As before, data points are shown with black triangles.

Figures 5-1 through 5-16 show that contaminant distributions for the different COCs are similar in area and depth. For example, when used with Figure 4-2, Figures 5-1, 5-5, 5-9, and 5-13, all can be seen to show peaks in the concentration contours in the vicinity of CRU-1 and numerous peaks in CRU-3 in the area east of the plant. On each figure, the number of peaks in the contoured surfaces are similar (i.e., they tend to be located generally in the same geographic areas and the closed contours tend to center on the same locations). No major anomalies are present, such as an area of closely spaced contours which appears on only one figure. Soils in areas which are relatively high in U-total or U-238 typically correspond with areas which are relatively high in Th-230 or Th-232. While the estimated concentrations for thorium do not exceed the action levels, soils high in thorium would be excavated with soils which exceed the U-total action level. Based on the action levels presented in Table 2-1 and the CSVs presented in Section 4 for the four COCs, the CSV for U-total provides the best indicator of the volume of contaminated soil which may require excavation.

Figure 5-17 shows the distribution of U-total in the interval between 0 and 2 feet. Table 4-5 showed that the majority of soil which may require excavation is in this layer. Therefore, Figure 5-17 provides an indication of areas in which excavation may be required.

Figure 5-17 was created using the INTEGRAPH system and a file of gridded data created on a personal computer using the methods described in this report. The stippled area of Figure 5-17 includes areas where U-total concentrations are above the action level of 35 pCi/g in the 0-2 feet layer. As stated in Section 2, 35 pCi/g is equivalent to 76 ppm of U-total (depleted). The stippled area was defined as any area where the estimated U-total concentration exceeded the logarithm of 76 which is approximately 1.88.

Table 5-1 lists the area of individual stippled areas shown on Figure 5-17 where the estimated U-total concentrations exceeded the action level. Table 5-1 also shows an estimate of the CSV in each of these areas based on areas calculated using the INTEGRAPH area functions. The result is 98 percent of the volume shown in Table 4-2 which was calculated using the methods described in Sections 2 and 3. The difference probably is due to differences in area interpolation by the two software packages.

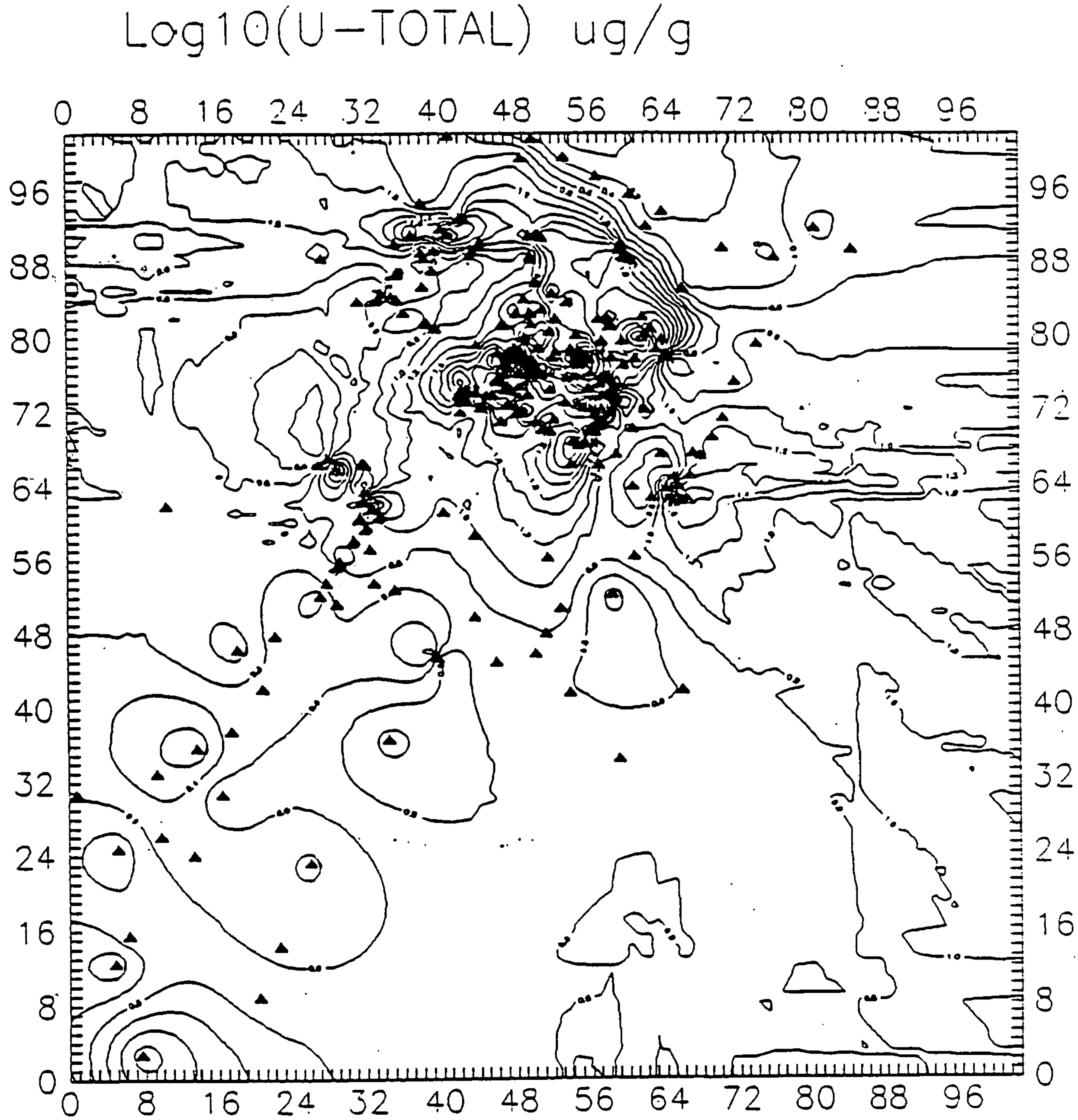

Figure 5-1 - Distribution of U-Total in Site Soils for the Layer 0-2 Feet

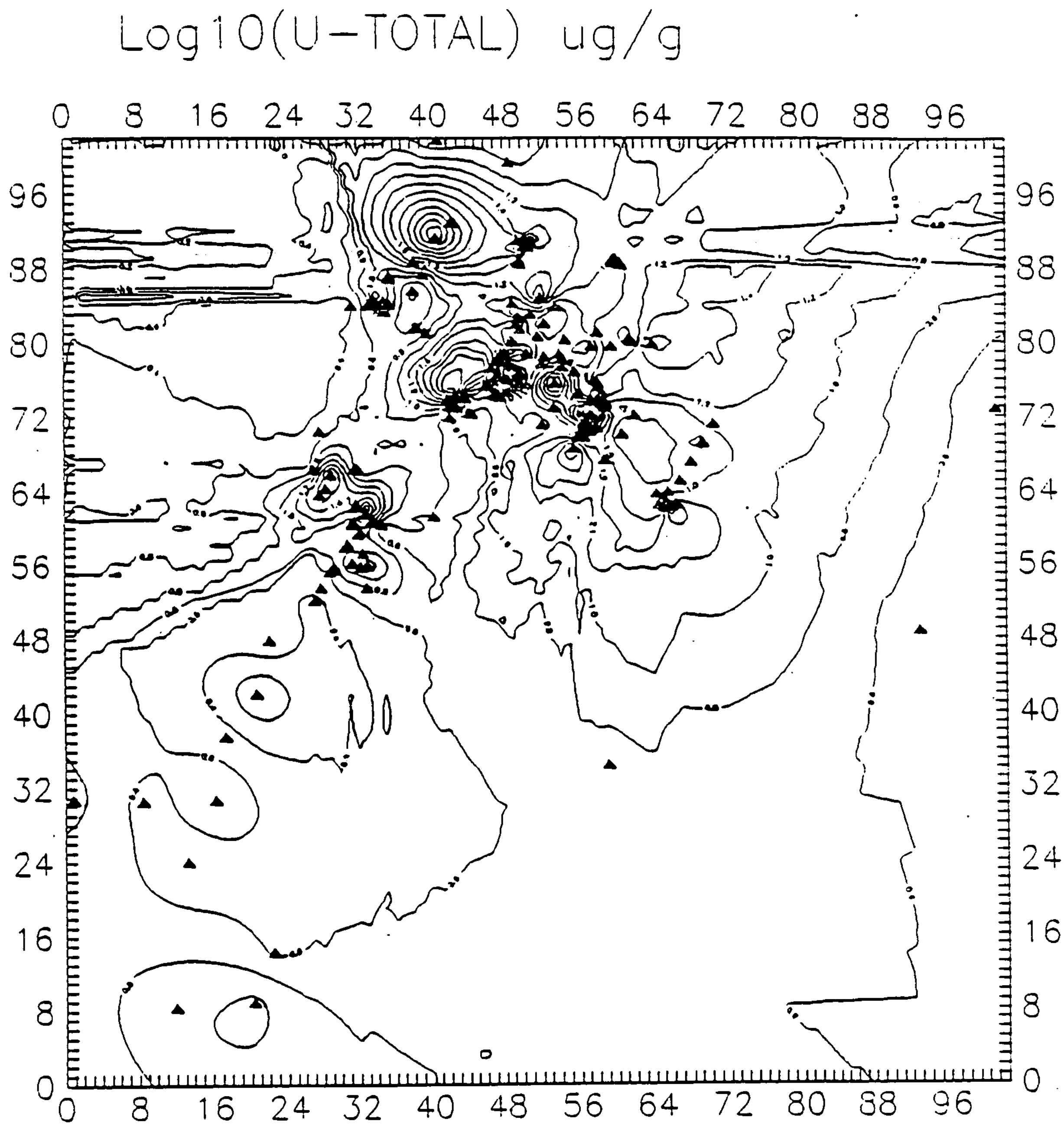

Figure 5-2 - Distribution of U-Total in Site Soils for the Layer 2-5 Feet

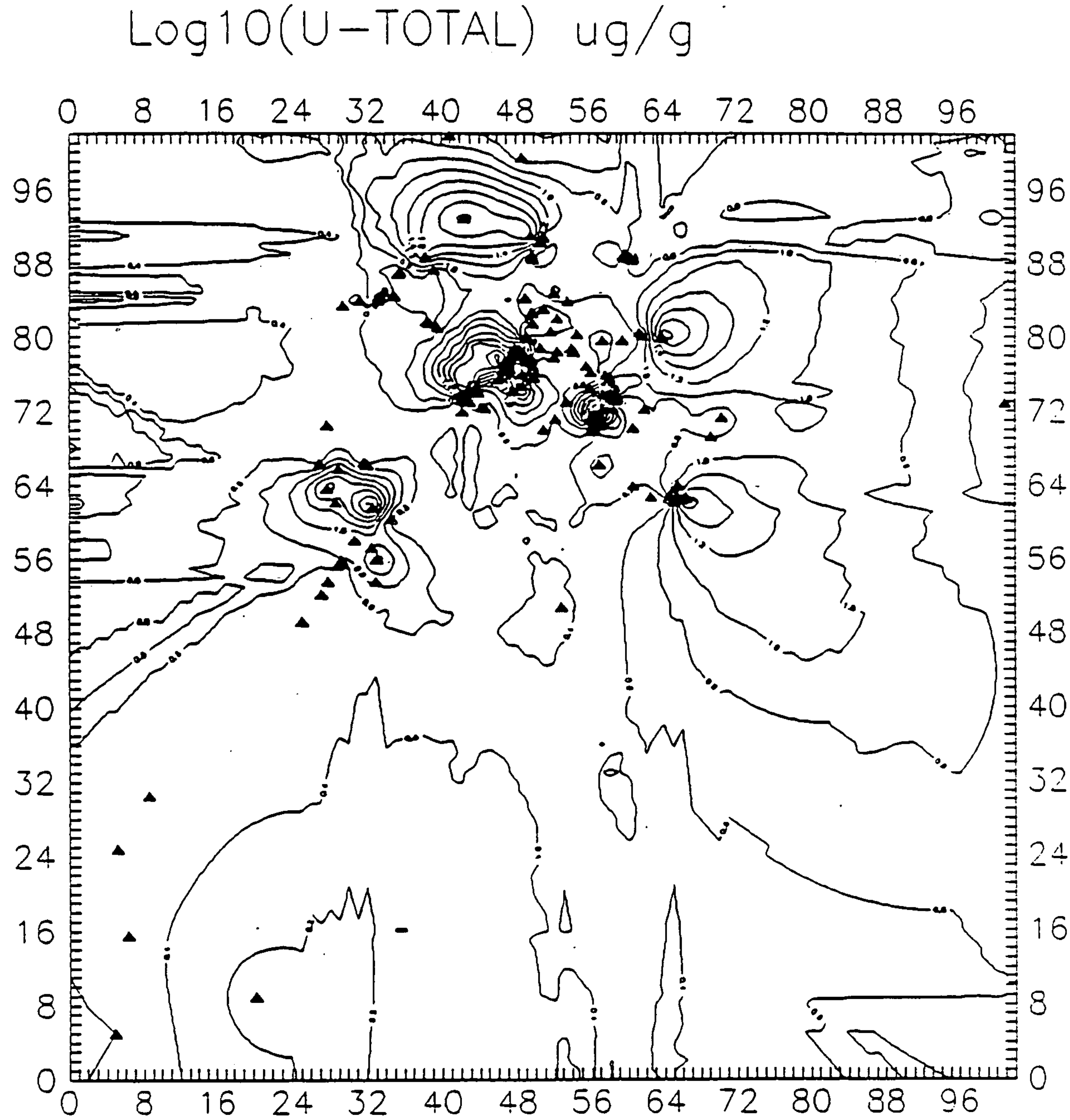

Figure 5-3 - Distribution of U-Total in Site Soils for the Layer 5-10 Feet

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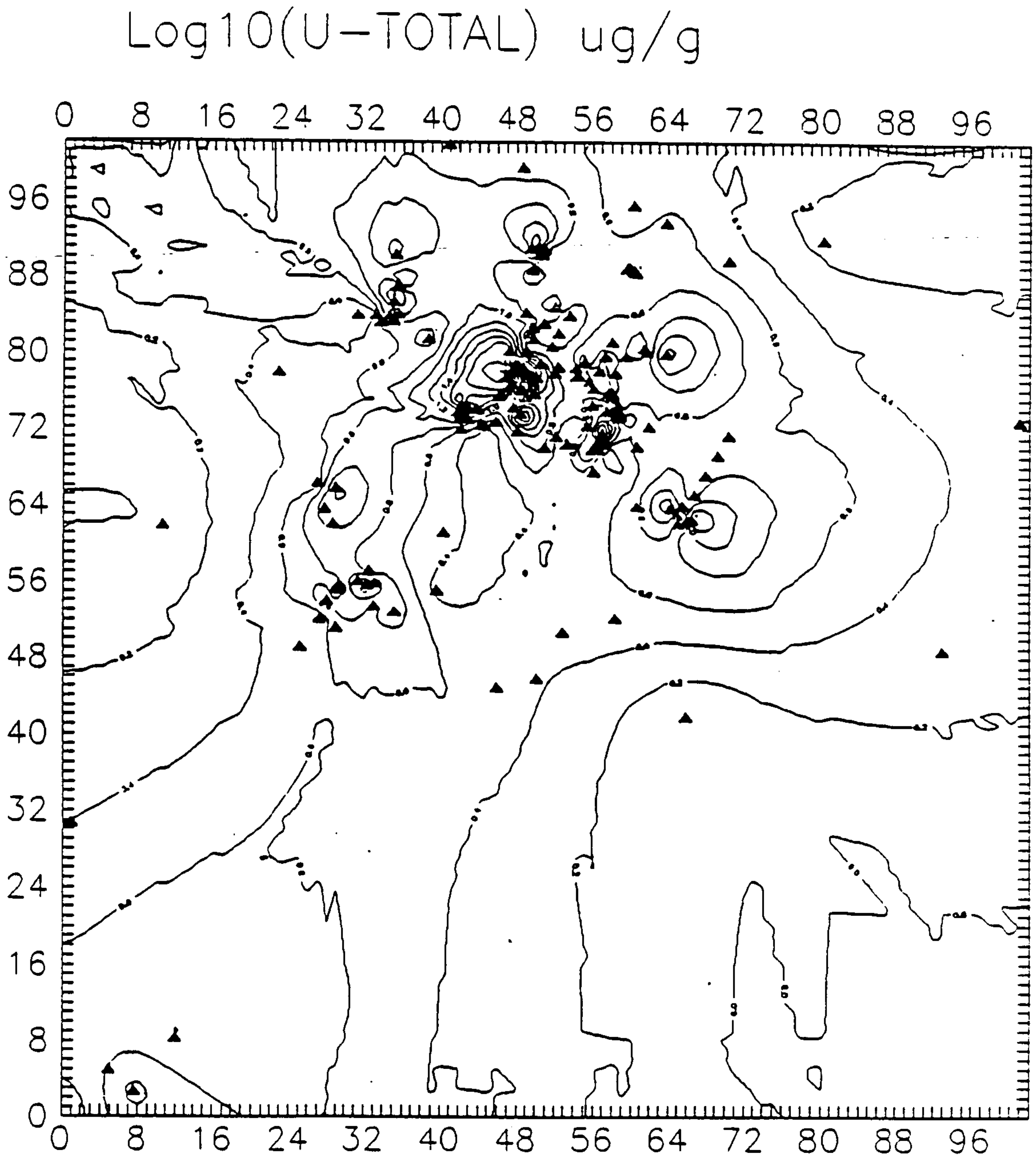

Figure 5-4 - Distribution of U-Total in Site Soils for the Layer 10-20 Feet

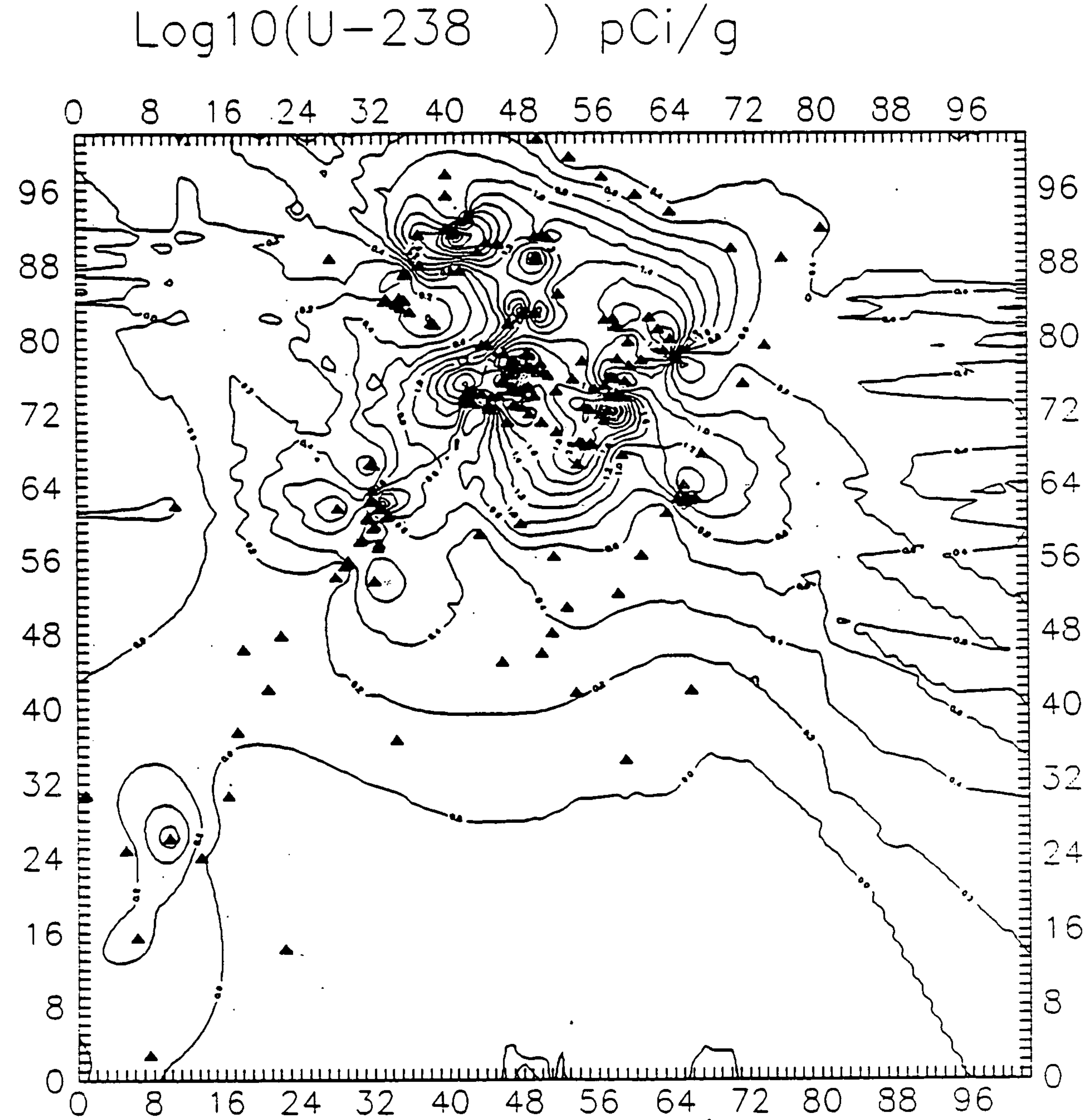

Figure 5-5 - Distribution of U-238 in Site Soils for the Layer 0-2 Feet

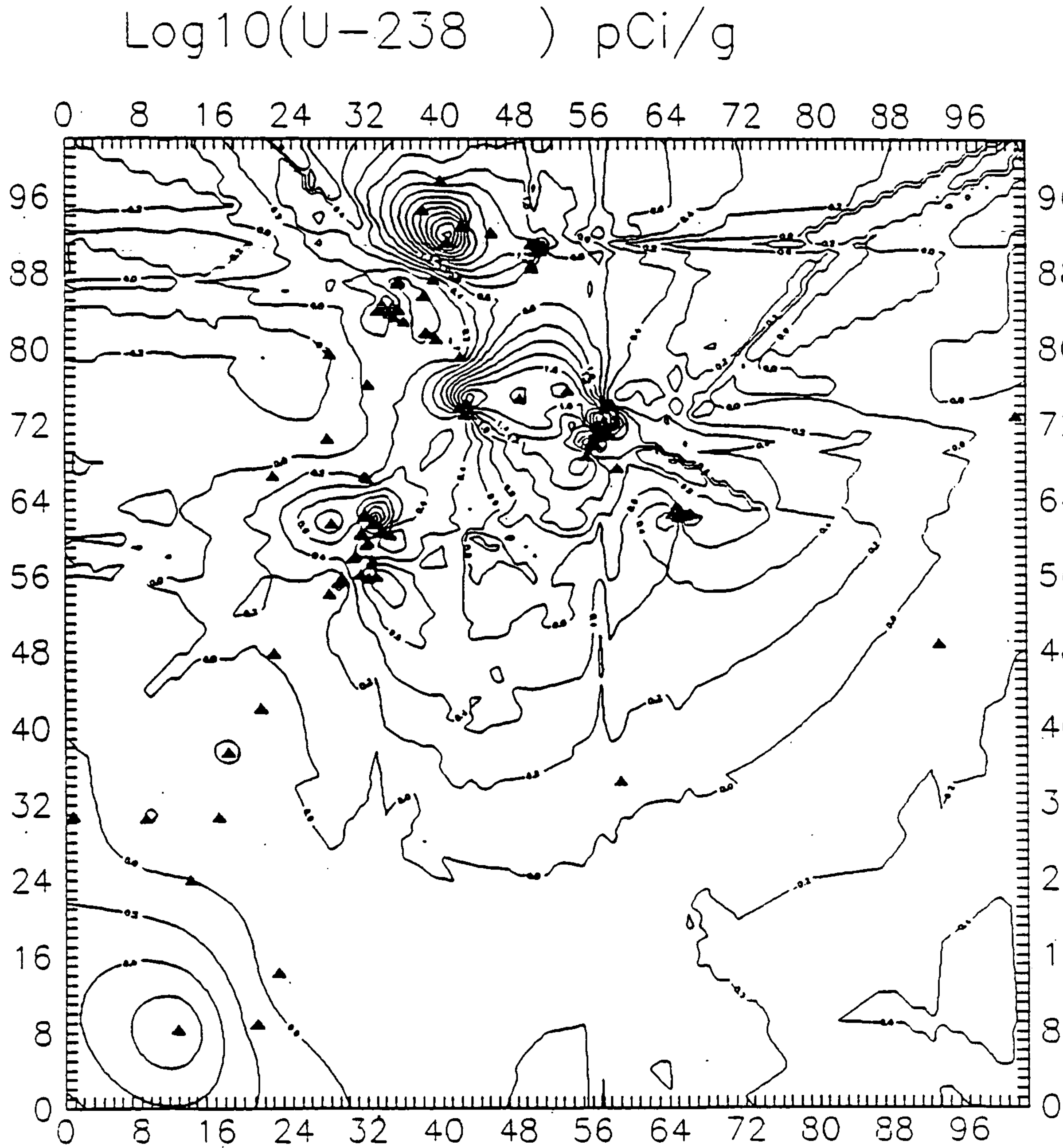

Figure 5-6 - Distribution of U-238 in Site Soils for the Layer 2-5 Feet

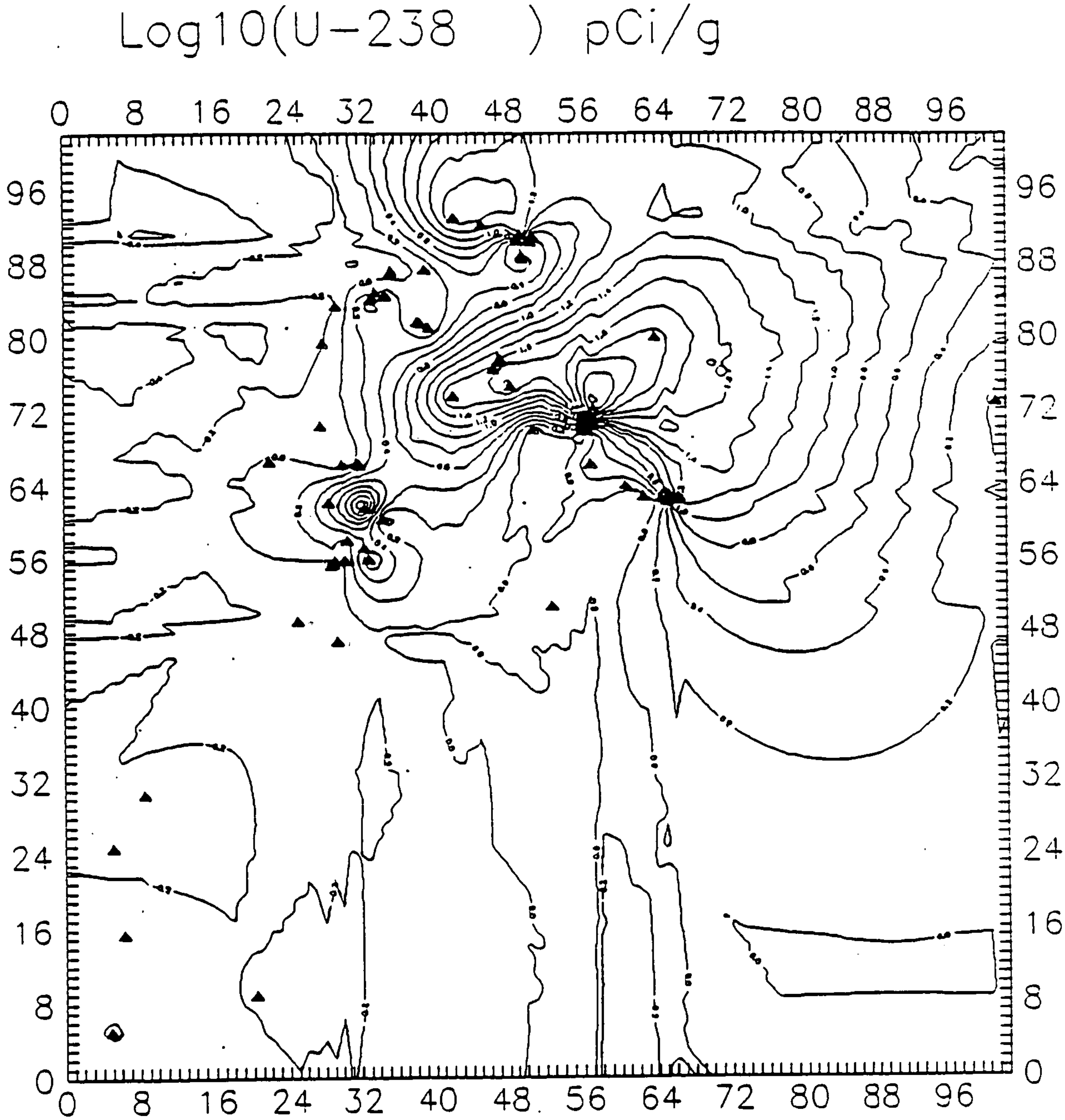

Figure 5-7 - Distribution of U-238 in Site Soils for the Layer 5-10 Feet

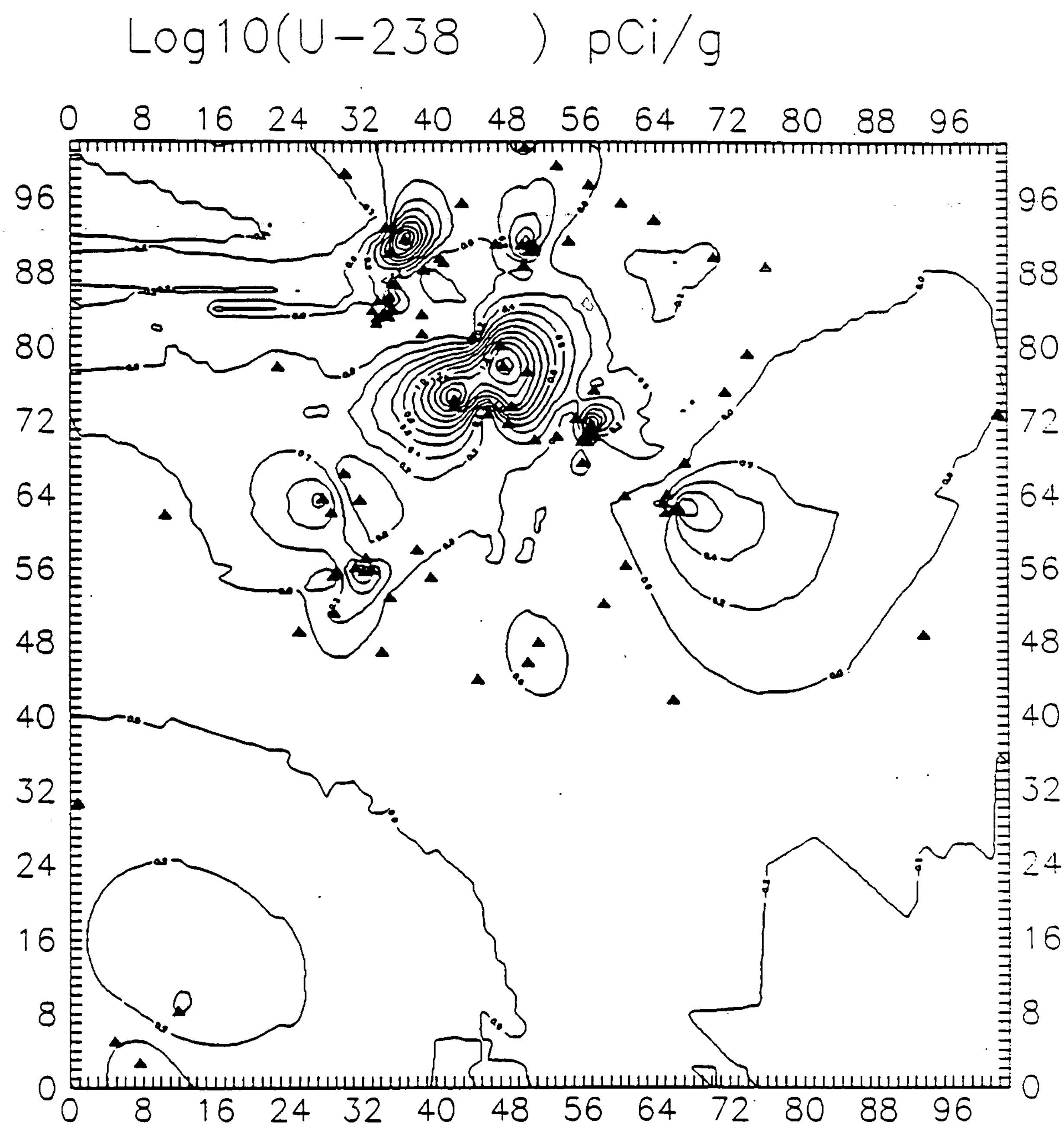

Figure 5-8 - Distribution of U-238 in Site Soils for the Layer 10-20 Feet

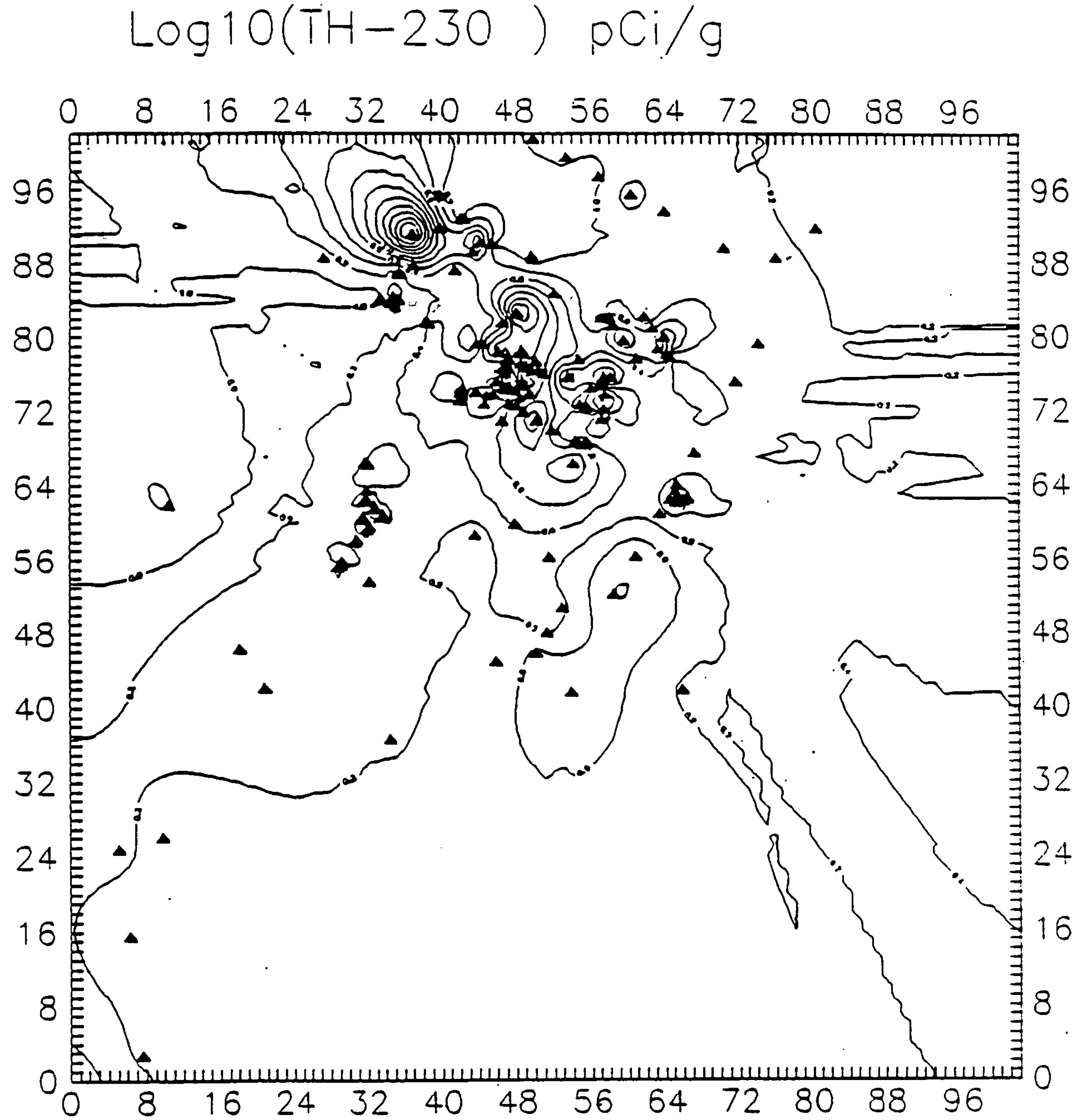

Figure 5-9 - Distribution of Th-230 in Site Soils for the Layer 0-2 Feet

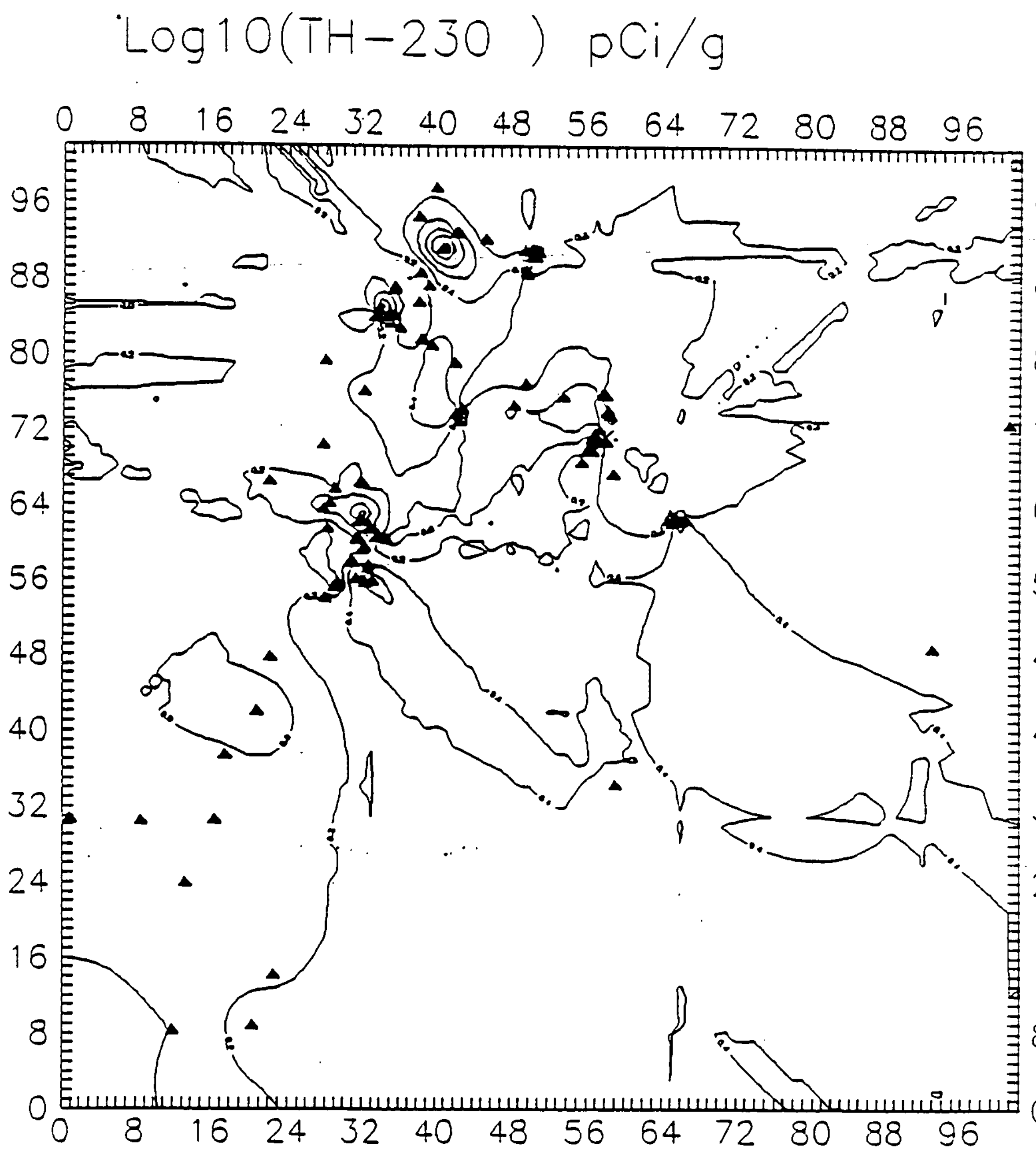

Figure 5-10 - Distribution of Th-230 in Site Soils for the Layer 2-5 Feet

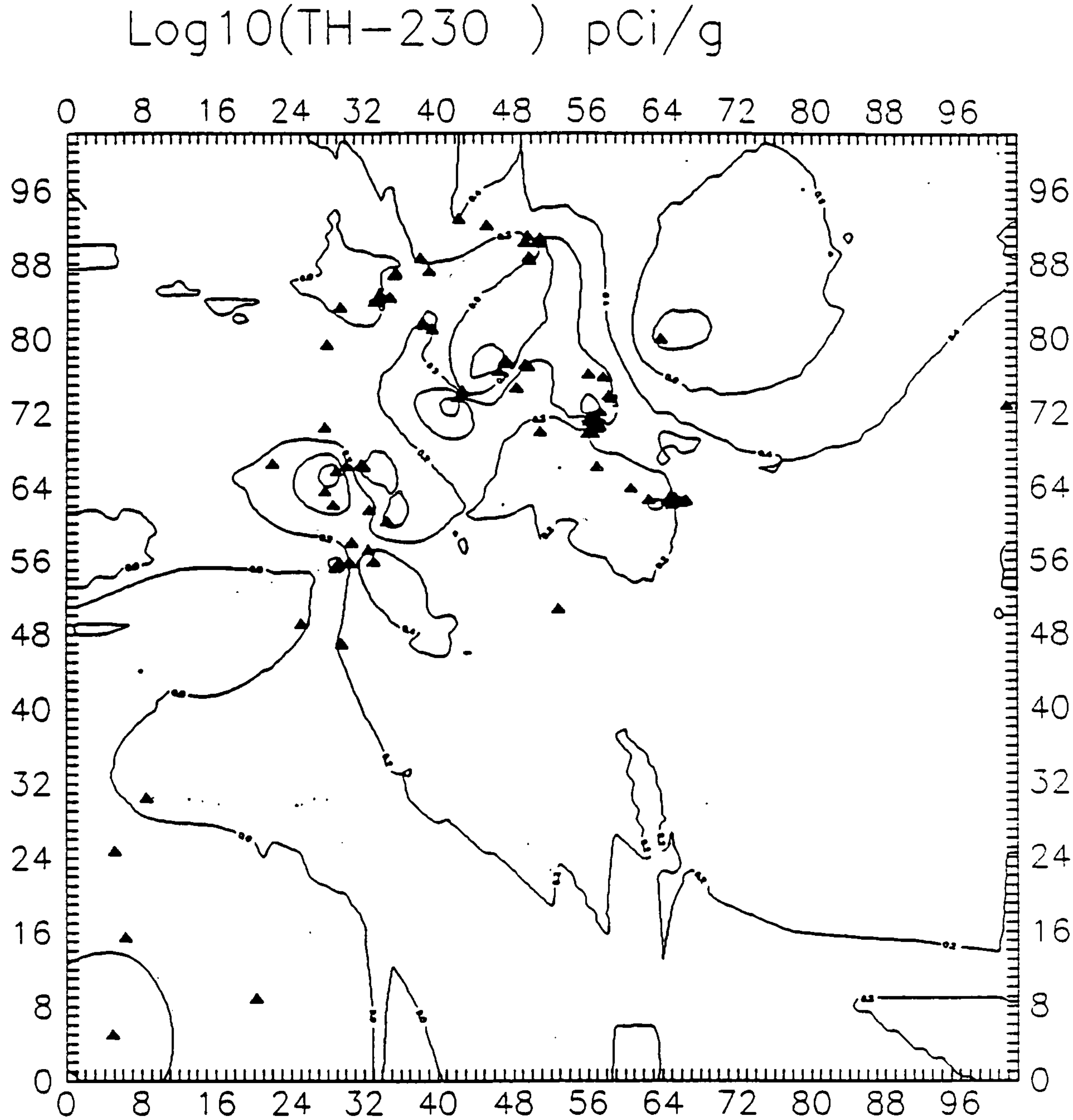

Figure 5-11 - Distribution of Th-230 in Site Soils for the Layer 5-10 Feet

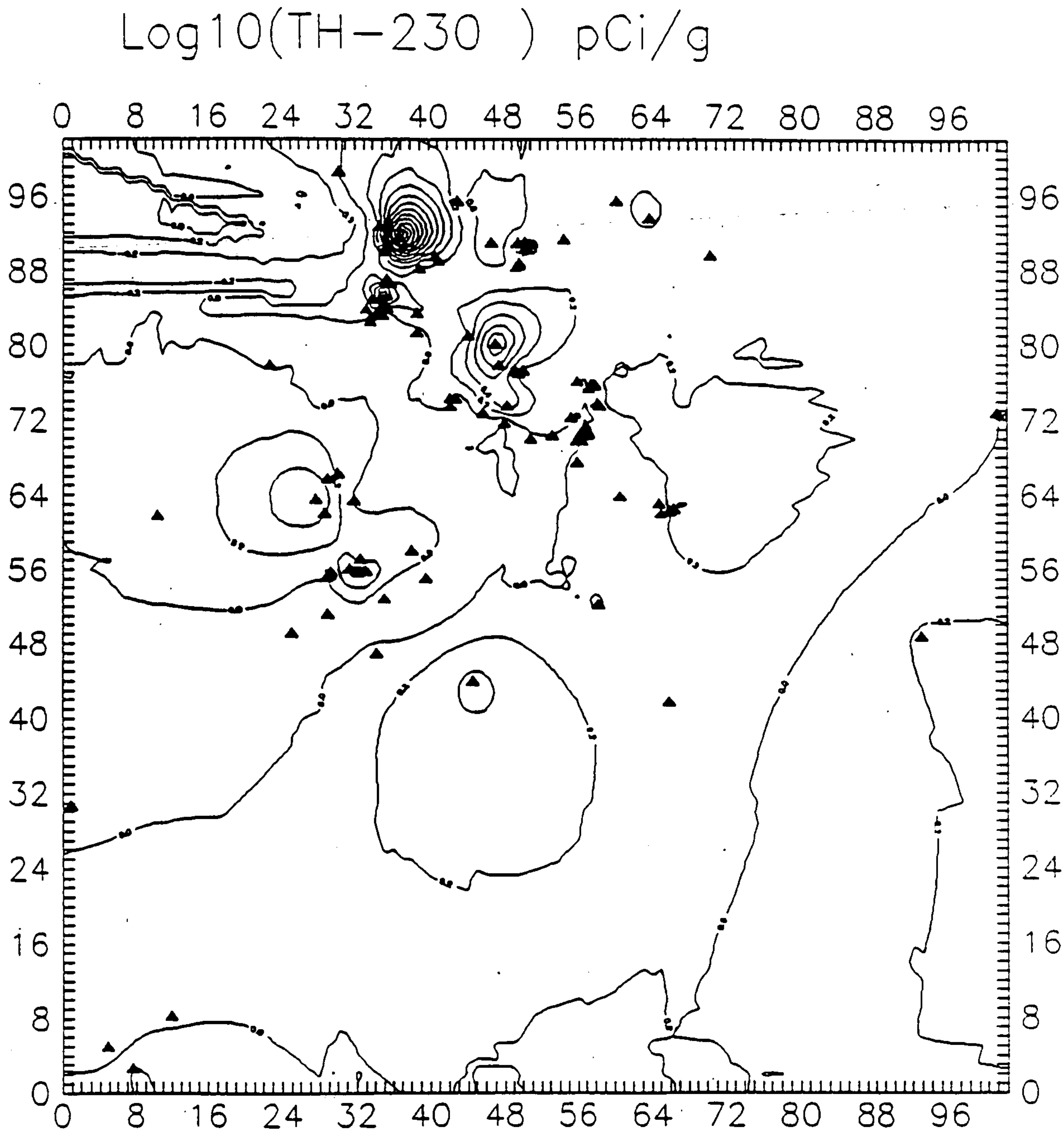

Figure 5-12 - Distribution of Th-230 in Site Soils for the Layer 10-20 Feet

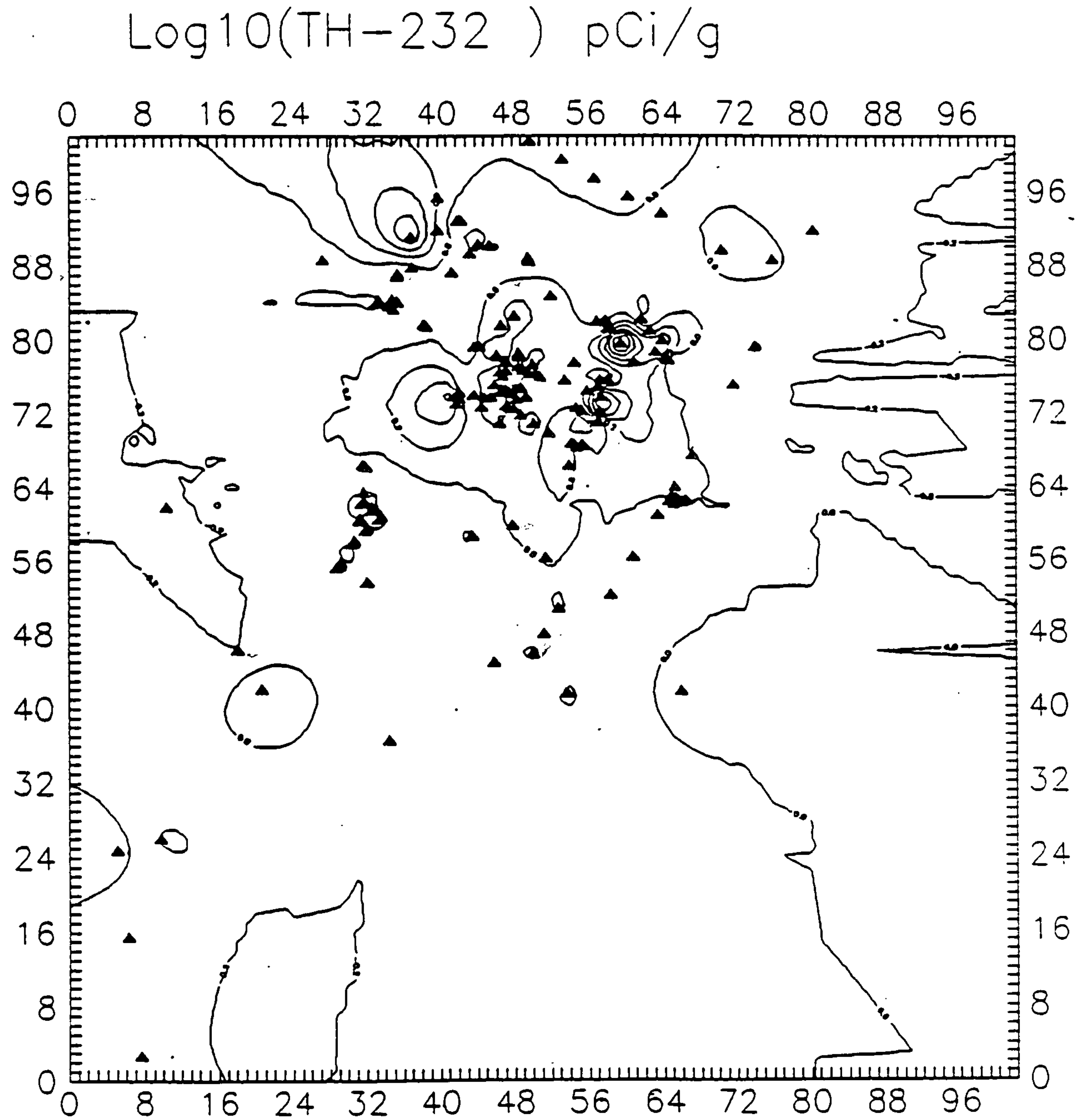

Figure 5-13 - Distribution of Th-232 in Site Soils for the Layer 0-2 Feet

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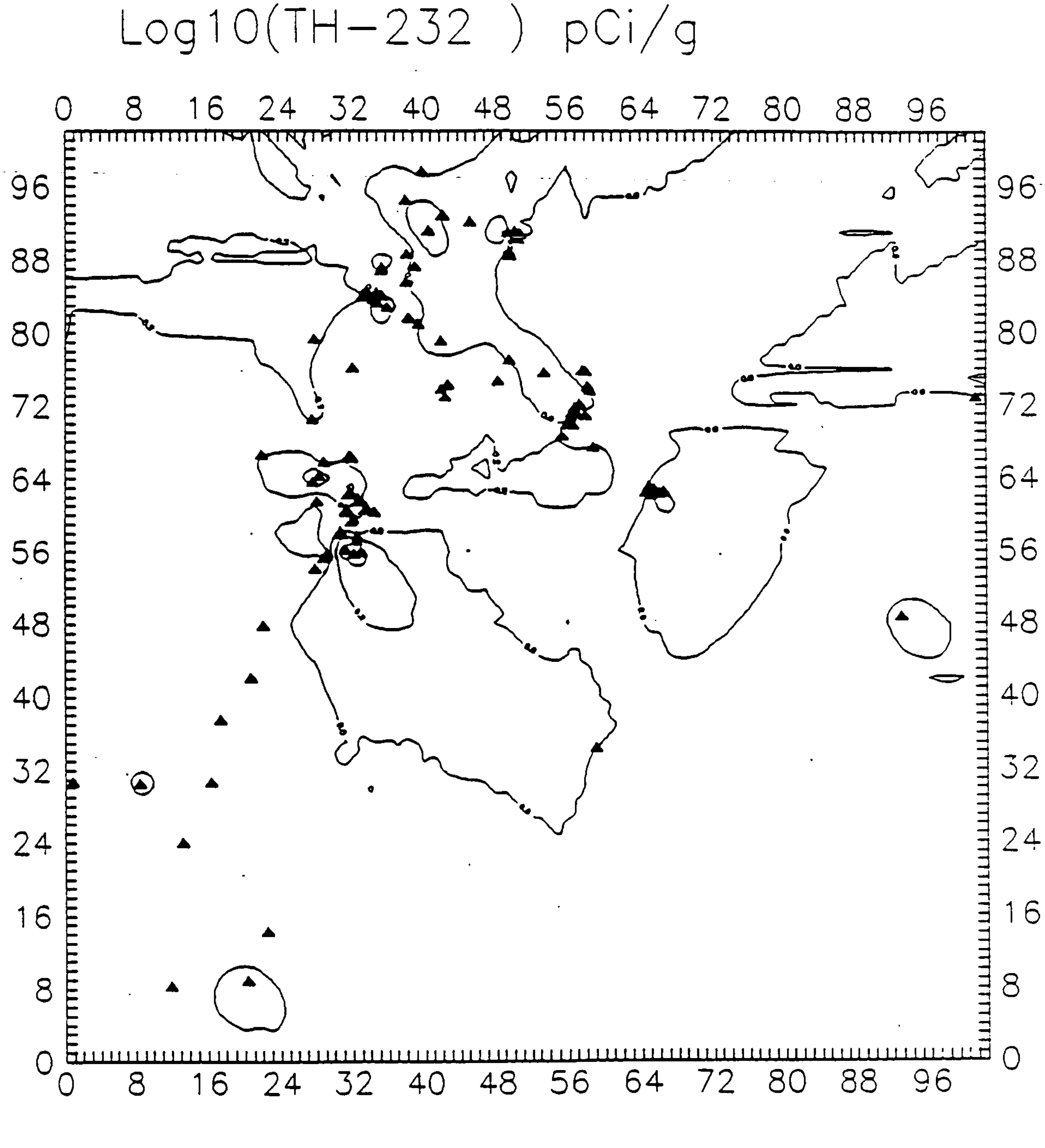

Figure 5-14 - Distribution of Th-232 in Site Soils for the Layer 2-5 Feet

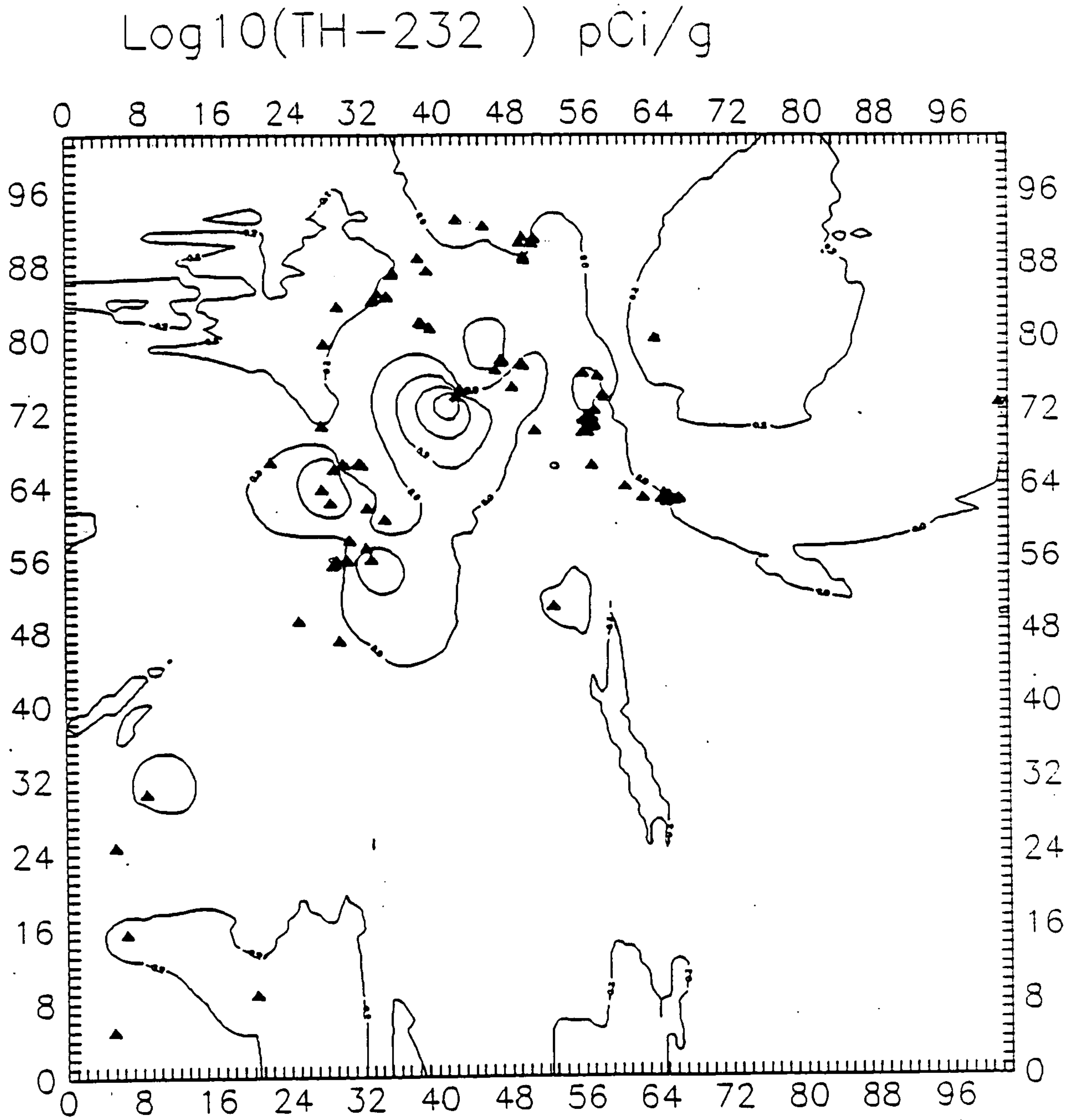

Figure 5-15 - Distribution of Th-232 in Site Soils for the Layer 5-10 Feet

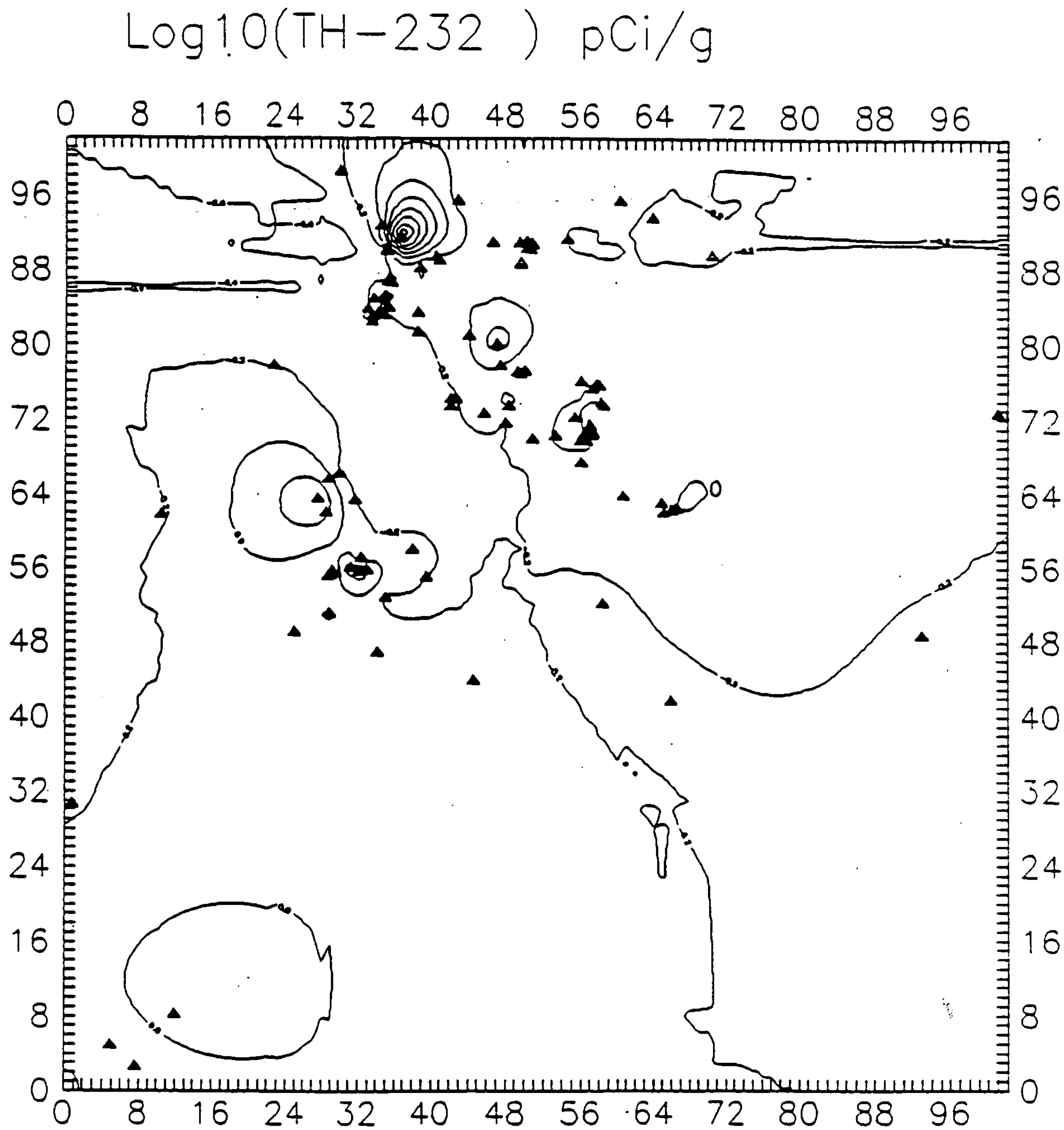

Figure 5-16 - Distribution of Th-232 in Site Soils for the Layer 10-20 Feet

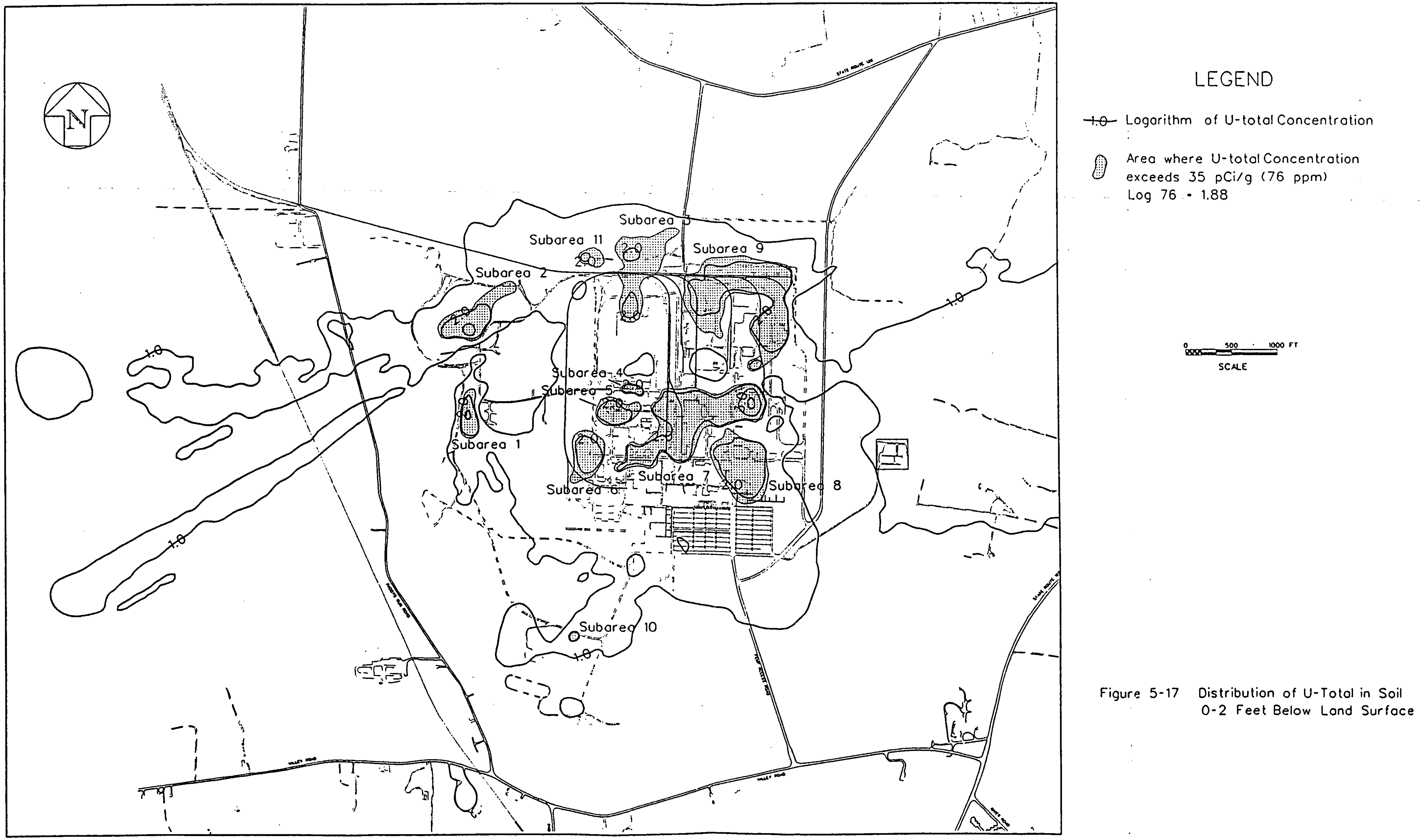

Figure 5-17 Distribution of U-Total in Soil 0-2 Feet Below Land Surface

/usr/era/ou5/po81/erma/po81/
dgn/map/hor/dpth/skx02423.dgn

Figure 5-17 - Distribution of U-Total in Site Soils for the Layer 0-2 Feet (by INTERGRAPH CAD)

Table 5-1 - Areas and Volumes of U-Total Contaminated Soil in the 0-2 Feet Layer

Subarea No.	Area (square feet)	Volume (cubic yards)
1	86,947	6,441
2	225,470	16,703
3	341,350	25,287
4	27,882	2,065
5	116,025	8,595
6	163,612	12,120
7	765,744	56,726
8	367,004	27,188
9	827,153	61,275
10	12,224	906
11	45,386	3,362
Totals	2,978,797	220,669

Note: Subarea locations are shown in Figure 5-17.

SECTION 6

CONCLUSIONS

Methods of contouring based on spatial interpolation are not entirely adequate in problems involving contamination transport within industrial areas. More sophisticated schemes could be developed for this purpose in order to construct a more reliable system of analysis. These schemes must include explicit information about media in which the transport processes are unfolding. An analytical or numerical model of transport processes should be used for the data assimilation and parameter estimation. Nevertheless, methods of spatial interpolation are useful for preliminary analysis and screening. Details of distribution within small areas are subject to strong fluctuations and can serve only as the order-of-magnitude estimations. The same can be said about the CSV estimations.

The figures in Section 5 reveal that distributions of different constituents are often similar. This circumstance is important from a practical perspective. It suggests that removing the volume of soil highly contaminated with a key contaminant (e.g., U-total) results in the removal of soils contaminated with other constituents as well.

Developing reliable remediation criteria is a very difficult problem, much more so than the soil quantification. In this situation, alternative approaches to soil quantification may be desirable. One alternate approach could consist of using only those criteria which are currently considered the most reliable. U-total is suggested for the role of this "key" contaminant. The fate of soils containing other contaminants, with less established criteria for PRGs, could then be investigated based upon the removal of soils containing uranium.

Both the revised CSV estimates (Table 4-2) and the excavated soil volume estimates (Table 4-4) are less than the volumes initially estimated (Table 4-1) using Figure 4-1. This is primarily due to an averaging feature of the volume estimating software. By spatially interpolating between scattered data points in a 0-20 feet layer, the software artificially inflates the CSV estimates. By segmenting the layer into several thinner layers, a more accurate aggregate CSV estimate is obtained.

The figures in Section 5 show that data is not distributed uniformly across the site. Because contamination sources are well known based on the operational history of the FEMP, more data is available close to known contamination sources. It would be reasonable to expect that contamination concentrations would decrease with distance from the known source. However, confidence in the CSV estimates would also decrease due to less data being available for analysis.

From Table 2-1, it can be shown that the number of measurements (data points) per feet decreases with the depth of each layer. Therefore, the confidence in the CSV estimates for each layer will decrease as depth increases. The more measurements that are available in each layer, the more accurate the CSV estimate.

Based on available soil monitoring data, the volume of soil contaminated with U-total at levels greater than 35 pCi/g (76 ppm) is estimated to be about 600,000 cubic yards (Table 4-2). Roughly 40 percent of these contaminated soils are in the 0-2 feet layer, 25 percent are in the 2-5 feet layer, 20 percent are in the 5-10 feet layer, and about 15 percent are in the 10-20 feet layer. Seventy percent of the estimated CSV is in OU-3.

It can be concluded that 800,000 cubic yards is a reasonable lower limit for the estimated volume of soil requiring excavation. Due to the lack of adequate soil monitoring data in subsurface soils, especially in the waste pits area, no upper limit estimate can reasonably be established at this time.

As additional data is made available by FERMCO, both the CSV estimate and associated excavated soil volume estimate can be revised with greater confidence.

SECTION 7

GLOSSARY

Gaussian Distribution

The most fundamental function of mathematical statistics. A Gaussian distribution is a symmetrical, bell-shaped continuous distribution of accidental errors about their mean (Chow 1964). Its importance follows from the CENTRAL LIMIT THEOREM which states that the sum of a large number of arbitrarily distributed random values has a Gaussian Distribution ("The Law of Large Numbers") (Korn 1968).

Kriging

Method of spatial interpolation in which the weight of coefficients are calculated via a spatial correlation function of the sample field.

Normal Distribution

The same as Gaussian Distribution.

Normal Equations

System of linear algebraic equations resulting from the method of Gaussian (normal) regression.

SECTION 8

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ATTACHMENT A

PRELIMINARY REMEDIATION GOALS

PRELIMINARY REMEDIATION GOALS

The constituents of concern for the Project Order 81 Soil Characterization and Quantification Study Report were selected from Table 2-3 of Part III of Appendix 7 of the DOE's *Site-Wide Characterization Report*[1]. The preliminary remediation goals for these constituents are being used since neither Remedial Action Objectives nor action levels have been determined.

To obtain an estimate of the amount of soil requiring excavation and treatment/disposal, 18 of the constituents listed in the *Site-Wide Characterization Report* were chosen as "key constituents". These contaminants were selected based upon their prevalence in FEMP soil and/or their toxicity. The goals used for these contaminants were based upon the preliminary remediation goals for residential and recreational land use. Recent direction indicated that the goals for recreational land use will be used to develop a conservative estimate of the amount of soil requiring excavation.

Preliminary remediation goals based upon dose limits were chosen for radionuclides. The goals were based upon a 100 mrem dose limit for exposures to the general public (10 CFR 20) and Committed Effective Dose Equivalent Dose Conversion Factors from EPA. The calculated dose-based goals were divided by 100 to account for the fact that the 100 mrem limit is for all exposures, while the goals are for single exposure pathways and radionuclides.

The only radionuclide goal that was not developed based upon the 100 mrem dose limit was that for total depleted uranium. The goal for total depleted uranium was based upon Nuclear Regulatory Commission Branch Technical Position on "Disposal or On-Site Storage of Residual Thorium or Uranium (either as natural ores or without daughters present) from Past Operations and the proposed rule for 10 CFR 834. The preamble of proposed 10 CFR 834 - the codification of DOE Order 5400.5 - states that the limit of 35 pCi/g was developed from the RESRAD Code and associated implementation manual and ALARA principles. Forty-seven properties in New York were remediated under the DOE Formerly Utilized Sites Remedial Action Program. The cleanup of the 47 properties under this standard were evaluated. The average maximum potential dose from post-remedial action use of the sites was less than 1 mrem per year (58 FR 16276).

For chemical constituents of concern, goals developed based upon a 10^{-6} risk for incidence of cancer were used because the goals account for multiple contaminants. In cases where this goal was not available for a given constituent, goals developed using equations and parameters for soil ingestion and chemical-specific Reference Doses from the *Health Effect Assessment Summary Tables* and the Integrated Risk Information System were used.

[1] *Site-Wide Characterization Report*, March 1993. FEMP-SWCR-3.

PRELIMINARY REMEDIATION GOALS
(based upon recreational land use)

RADIONUCLIDES	
Constituent	Action Level (pCi/g)
Lead-210	155
Radium-226	3.8
Radium-228	7.7
Thorium-228	4
Thorium-230	1,520
Thorium-232	305
Uranium (depleted)	35

CHEMICALS	
Constituent	Action Level (mg/kg)
Antimony	1,050
Arsenic	780
Beryllium	16
Lead	1,800
Mercury	780
Aroclor-1254	18
Aroclor-1260	18
Benzene	4,800
Benzo(a)pyrene	24
DDT	400
Tetrachloroethene	2,700

ATTACHMENT D

SOIL REMEDIATION SCHEDULE STUDY

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Soil Remediation Schedule Study

Operable Unit 5
Project Order 81
November 1993
Revision A

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio
FERMCO Subcontract No. 2-21487

PARSONS

Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

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Soil Remediation Schedule Study

Operable Unit 5
Project Order 81
November 1993
Revision A

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio
FERMCO Subcontract No. 2-21487

PARSONS

Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

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Soil Remediation Schedule Study

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LIST OF ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRU	CERCLA/RCRA Unit
CSF	Central Storage Facility
CY	Cubic Yard
D&D	Decontamination and Dismantling
DOE	United States Department of Energy
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FY	Fiscal Year
Kg/day	Kilograms per day
MAWS	Minimum Additive Waste Stabilization
OU	Operable Unit
pCi/g	picoCuries per gram
PO	Project Order
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RI/FS	Remedial Investigation/Feasibility Study
SCQS	*Soil Characterization and Quantification Study*
US EPA	United States Environmental Protection Agency

SECTION 1

INTRODUCTION AND OBJECTIVES

During 38 years of operation (1951-1989), the Fernald Environmental Management Project (FEMP) site soils received varying amounts of uranium contamination resulting from emissions and accidental spills. In addition, some FEMP site soils received organic and inorganic contaminants via similar mechanisms.

The United States Department of Energy (DOE) is currently undergoing the Remedial Investigation and Feasibility Study (RI/FS) process at the FEMP. The RI/FS is the blueprint for cleanup at the FEMP. This process is being conducted under an Amended Consent Agreement between the DOE and the United States Environmental Protection Agency (US EPA) executed on September 20, 1991. The RI/FS will lead to issuance of a Record of Decision (ROD) establishing Remedial Action Objectives (RAOs) for each FEMP Operable Unit (OU).

No standards currently exist for radiological contamination levels in soil (other than radium). However, according to the US EPA-approved *Treatability Study Work Plan for Operable Unit 5 Soil Washing* (DOE 1992a), an action level of 35 pCi/g is consistent with levels set by the Nuclear Regulatory Commission Branch Technical Position, "Disposal or On-Site Storage of Thorium or Uranium Wastes from Past Operations," as published in the *Federal Register* on October 23, 1981, and levels included in proposed 10 CFR 834. The 35 pCi/g treatment goal is not intended to supplant establishment of RAOs under the ROD for each OU. Soil washing was one of several alternative treatment technologies identified for the remediation of FEMP soils in the *Initial Screening of Alternatives for Operable Unit 5* (DOE 1992b).

Large portions of the FEMP production area currently have total uranium concentrations greater than 35 pCi/g in soil depths up to 1.5 feet. Total uranium concentrations greater than 35 pCi/g below 1.5 feet are primarily restricted to certain production and maintenance facilities. Concentrations of total uranium in FEMP soils outside the production area and the waste storage area are generally less than 35 pCi/g. Exceptions include suspect areas such as the Fire Training Area, the Sewage Treatment Plant area, and the rubble mound west of the K-65 Silos. Organic contamination occurs near facilities where chemicals were used for process development or in conjunction with machining and maintenance operations.

The objective of the Soil Remediation Schedule Study is to analyze current OU remediation schedules and plans to determine their impact on current CERCLA/RCRA Unit 5 (CRU-5) soil remediation schedules and plans. FERMCO has provided an Integrated Site Master Schedule (FERMCO 1993) which outlines the remediation schedule for each OU. In addition, PARSONS has met with representatives of each FERMCO CRU and received contaminated soil volume estimates for each OU. PARSONS used the results of the draft *Soil Characterization and Quantification Study* (SCQS) (PARSONS 1993b), the FERMCO CRUs' contaminated soil volume estimates, and current OU remediation schedules to prepare an integrated soil remediation schedule. PARSONS also developed a recommended soil remediation schedule and plan, consistent with the OUs' remediation plans, to better define the material (soil) flow requirements. The recommended soil remediation schedule and plan will be used as part of the technical basis for the Project Order (PO) 81 Conceptual Design Report.

SECTION 2

ESTIMATION OF CONTAMINATED SOIL QUANTITIES

Estimates of in situ contaminated soil quantities were obtained from both the FERMCO CRUs and the draft SCQS (PARSONS 1993). In cases of conflicts between FERMCO CRU estimates and SCQS estimates of contaminated soil quantities, the most conservative estimate was adopted for use in this study.

PARSONS met with representatives of each FERMCO CRU to discuss their OU remediation schedules and plans, and their estimates of the quantities of contaminated soils requiring treatment. These meetings were documented in PARSONS Meeting Minutes dated August 9, 1993 (05:081:100:0652-93) (see Appendix A).

2.1 Assumptions

PARSONS assumed the following in preparing this study:

1) FERMCO CRU-5 anticipates one 20 ton/hour soil washing system operating from the end of fiscal year (FY) 1997 through FY 2018. Due to the uncertain nature of current contaminated soil quantity estimates, FERMCO CRU-5 will retain the flexibility to extend the operating life or add additional soil treatment capacity if warranted.

2) Soils will be excavated based on the current OU remediation schedules as contained in the Integrated Site Master Schedule (FERMCO 1993). The excavated soil volume estimates were spread out over time, based on the OU remediation schedules (e.g., equal portions of the soil caps on the OU-1 Pits 1 through 4 will be excavated throughout the time period the pits are remediated. However, Pits 5 and 6 soils will not be excavated until remediation of those pits is completed).

3) Excavated soil will be immediately transported to a soil stockpile.

4) The soil washing system capacity is rated in tons of soil processed per hour. Therefore, the estimates of contaminated soil volume were multiplied by an in situ density factor in order to obtain mass estimates of soil requiring treatment. The following in situ density factors were applied:
   (1) 1.35 tons/CY for existing soil stockpiles
   (2) 1.76 tons/CY for all other soils

5) In situ soil volumes must be multiplied by a swell factor of 1.3 to obtain ex situ soil volumes.

6) The soil washing system will operate continuously, 365 days per year, three 8-hour shifts per day.

7) The soil washing system will have an on-stream factor of 85 percent. The on-stream factor allows for downtime due to maintenance, holidays, and unplanned equipment outages.

8) The soil washing system will have a processing efficiency factor of 75 percent. The processing efficiency factor allows for variations in processing efficiency from rated capacity.

9) The composite processing factor is 62.5 percent ([.85][.75] ≐ .625). Thus, a 20 ton/hour system has a nominal processing capacity of 12.5 tons/hour. Therefore, a 20 ton/hour system operating 24 hours/day, 365 days/year will process approximately 109,500 tons of soil annually.

2.2 Basis for Estimates of In Situ Contaminated Soil Quantities

2.2.1 Existing Stockpiles

According to the *Operable Unit 3 Work Plan Addendum* (DOE 1993a), there are approximately 36,300 cubic yards (CY) of contaminated soil and rubble contained in controlled stockpiles. According to the *Facility Utilization Report* (DOE 1993b), controlled stockpiles are currently located North of Third Street, adjacent to Plant 1, South of Plant 8, South of Building 80, and North of Building 67. The Third Street stockpile is the largest controlled stockpile. It was closed in 1992 and contains approximately 23,300 CY of contaminated soil and rubble (PARSONS 1993a).

2.2.2 OU-1

The draft SCQS (PARSONS 1993b) estimated that OU-1 contained approximately 128,000 CY of contaminated soil.

FERMCO CRU-1 has estimated that OU-1 contains approximately 294,500 CY of contaminated soil requiring remediation. These contaminated soils are contained in the waste pit caps and liners, in soils under and adjacent to the waste pits, and in the Burn Pit. The FERMCO CRU-1 estimates of in situ contaminated soil quantities are documented in FERMCO Letter M:CRU3:93-0511 dated July 23, 1993 (see Appendix B). The FERMCO CRU-1 estimate was used for this study.

2.2.3 OU-2

The draft SCQS (PARSONS 1993b) estimated that OU-2 contained approximately 28,000 CY of contaminated soil.

FERMCO CRU-2 has estimated that OU-2 contains approximately 85,850 CY of soil requiring remediation. These contaminated soils are contained under the Active Fly Ash Pile, in the Inactive Fly Ash Pile cover and under the pile, under the Lime Sludge Ponds, in the Solid Waste Landfill, and in the South Field area. The FERMCO CRU-2 estimate is documented in FERMCO Letter M:CRU2:93-0246 dated July 20, 1993 (see Appendix C). The FERMCO CRU-2 estimate was used for this study.

2.2.4 OU-3

The draft SCQS (PARSONS 1993b) estimated that OU-3 contained approximately 428,000 CY of contaminated soil.

FERMCO CRU-3 has not prepared an independent estimate of the quantity of contaminated soils contained in OU-3. Instead, their estimate of 900,000 CY is based on an Enhanced Cost Study for Soil Remediation at the FEMP prepared by PARSONS in September 1992. This estimate was calculated by assuming that the first 1.5 feet of soil in the entire production are was contaminated. This estimate was used for this study.

2.2.5 OU-4

Due to a lack of soil monitoring data, the draft SCQS (PARSONS 1993b) was unable to estimate the quantity of contaminated soils contained in OU-4.

In the OU-4 Feasibility Study (DOE 1993c), FERMCO CRU-4 estimated that 29,629 CY of soil will require remediation. FERMCO CRU-4 assumes that all of the K-65 Silo berms and all the soils within 5 feet of the other silos will require remediation. The FERMCO CRU-4 estimate was used for this study.

2.2.6 OU-5

FERMCO CRU-5 has not prepared an independent estimate of the quantity of contaminated soils contained in OU-5. The draft SCQS (PARSONS 1993b) estimated that OU-5 contained approximately 20,000 CY of contaminated soil.

2.3 Summary

Table 2-1 presents the estimated in situ contaminated soil volumes to be excavated and treated in each FEMP OU.

Table 2-1 - In Situ Contaminated Soil Volumes (All Volumes are in Cubic Yards)

Source	SCQS Estimate	FERMCO Estimate	Volume Used
Existing Stockpiles	N/A	36,300	36,300
OU-1	128,000	294,500	294,500
OU-2	28,000	85,850	85,850
OU-3	428,000	900,000	900,000
OU-4	0	29,629	29,629
OU-5	20,000	N/A	20,000
Total	604,000	1,346,279	1,366,279

N/A = Not Available

SECTION 3

OPERABLE UNIT REMEDIAL ACTIVITIES

Figure 3-1 presents timelines of the OU remedial activities generating contaminated soil. The timelines are based on the OU remediation schedules contained in the Site Integrated Master Schedule (FERMCO 1993).

Decontamination and dismantling (D&D) of the OU-3 production area facilities, as well as any contaminated soils excavated during D&D, will be the responsibility of FERMCO CRU-3. FERMCO CRU-5 will be responsible for excavating remaining OU-3 contaminated soils. OU-3 underground utilities will remain in service throughout FEMP remediation efforts and will be one of the last items to be remediated.

The SCQS (PARSONS 1993b) indicated that OU-5 contaminated soils were primarily adjacent to the OU-3 production area. As a result, the OU-5 contaminated soils will be excavated along with the adjacent OU-3 contaminated soils.

In addition to the activities shown in Figure 3-1, the following remedial activities are associated with the treatment of contaminated soil or the residual contaminated fraction remaining after soil treatment:

1) The OU-1 Minimum Additive Waste Stabilization (MAWS) system provides soil washing, water treatment, and vitrification of the contaminated soil fraction remaining after soil washing. The MAWS system has an initial capacity of 300 kilograms per day (Kg/day) with an expansion capability to 1,000 Kg/day. The MAWS system may be used to vitrify the contaminated soil fraction from the OU-5 soil washing system. The MAWS system will begin operations in FY 1994.

2) Removal Action 17, Improved Storage of Soil and Debris, includes construction of proper storage facilities for soil and debris waste materials, including existing soil and rubble piles. A Central Storage Facility (CSF), with a storage capacity of approximately 13,500 CY, is currently scheduled to be completed in FY 1995. The CSF is intended to store soil contaminated with U-total greater than 100 pCi/g, total thorium greater than 50 pCi/g, and total radium greater than 5 pCi/g. Soil contaminated below these limits may be stored in controlled stockpiles.

3) FERMCO CRU-4 plans to operate a Vitrification Plant for the treatment of residual materials from the OU-4 silos. The OU-4 Vitrification Pilot Plant begins operations in FY 1995 to further develop the technology, obtain additional required design data, and demonstrate process applicability to the materials stored in the silos. The pilot plant data will be used to design the

	93	94	95	96	97	98	99	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OU-1				Pit 6		Pit 5 Pit 2 Cap	Pit 1 Cap Pit 2 Liner	Pit 1 Liner and Area Soils Pit 3 Cap	Pit 3 Cap	Burn Pit and Area Soils Pit 3 Cap	Pit 3 Cap Liner and Area Soils Pit 4 Cap	Pit 4 Liner and Area Soils													
OU-2				Solid Waste Landfill	Solid Waste Landfill Southfield	Inactive Fly Ash Pile Southfield	Inactive Fly Ash Pile Southfield	Inactive Fly Ash Pile	Lime Sludge Ponds Inactive Fly Ash Pile Active Fly Ash Pile																
OU-3								Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils	Production Area Soils
OU-4				K-65 Silo Berms	K-65 Silo Berms	K-65 Silo Berms Surface and Subsurface Soils	Surface and Subsurface Soils	Surface and Subsurface Soils	Surface and Subsurface Soils																
OU-5	Existing Soil Stockpiles		OU-5 FS Approval	OU-5 Draft ROD	Start of Soil Reme-diation	AWWT-III Operations Start						Soils Outside Production Area	Soils Outside Production Area	Soils Outside Production Area	Soils Outside Production Area	Soils Outside Production Area	Soils Outside Production Area								

Figure 3-1 - Remedial Activities Generating Contaminated Soil full-scale Vitrification Plant which is scheduled to begin operations in FY 1996. The Vitrification Plant may be used to vitrify the contaminated soil fraction from the OU-5 soil washing system.

4) The Advanced Wastewater Treatment facility (inclusive of Phases I, II, and III) provides for the treatment of uranium-contaminated process water, stormwater, and groundwater. PARSONS assumes that the AWWT will provide process water for the soil washing system and treat soil washing wastewater for reuse or discharge through an outfall to the Great Miami River or Paddy's Run. The AWWT is scheduled to be fully operational by FY 1998.

SECTION 4

CURRENT SITEWIDE SOIL REMEDIATION SCHEDULE

Table 4-1 presents the annual estimates of contaminated soil requiring treatment in each OU. This table is based on current OU remediation schedules as contained in the Integrated Site Master Schedule (FERMCO 1993) and the estimates of in situ contaminated soil quantities contained in Section 2. This table summarizes the soil quantity estimates by OU remediation element presented in Appendix D.

The five largest annual soil quantities are generated between FYs 2000 and 2004. The following remedial activities occur during this 5-year period:

1) OU-1 will remediate Pit 1, Pit 3, Pit 4, and the Burn Pit.

2) OU-2 will complete remediation of the Inactive Fly Ash Pile, Active Fly Ash Pile, and the Lime Sludge Ponds.

3) OU-3 will begin remediation of the production area soils.

4) OU-4 will complete remediation of the subsurface and surface soils.

5) OU-5 will begin remediation of the soils adjacent to the OU-3 production area.

Table 4-2 presents the quantity of contaminated soil generated annually, the quantity of contaminated soils treated annually, and the contaminated soil stockpile at the end of the FY. Approximately 91,258 tons of contaminated soil will be stockpiled by the time soil treatment starts in FY1998. This stockpile will include soil from existing stockpiles, Pit 6 soils, Solid Waste Landfill soils, and the K-65 Silo berm soils. In situ volume estimates are multiplied by 1.3 to obtain an uncompacted (ex situ) volume estimate. Thus, the soil stockpile at the start of soil treatment equates to approximately 78,400 CY of soil. The soil stockpile at the start of soil treatment would require a storage capacity equivalent to approximately six CSFs.

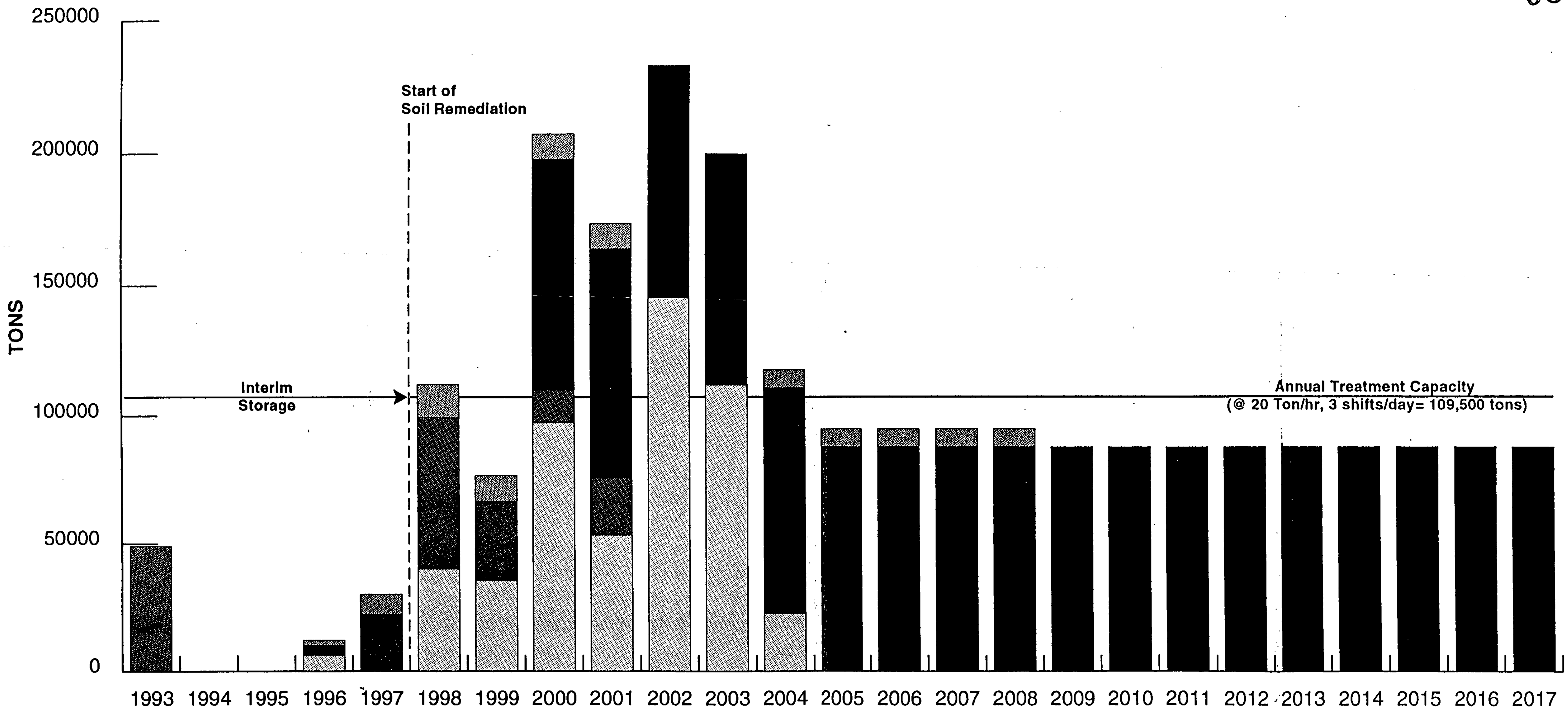
With the start of soil treatment in October 1997, the contaminated soil stockpile decreases steadily until FY 2000. During the peak soil generation years between FYs 2000 and 2004, the soil stockpile peaks at 445,864 tons (approximately 277,794 CY). At the end of soil washing operations in FY 2017, approximately 194,524 tons (123,087 CY) remain in stockpile. The soil washing system must operate approximately 22 additional months to eliminate the remaining stockpile. This information is provided graphically in Figure 4-1.

Tables of Contaminated Soil Generation (In Tons)

FY	(	OU-3	OU-4	OU-5	Total
1993	)	0	0	49,005	49,005
1996	;	0	1,987	0	12,019
1997	;	0	7,948	0	30,234
1998	.	0	12,748	0	112,098
1999	;	0	10,263	0	76,960
2000	;	88,000	9,601	0	207,548
2001	)	88,000	9,601	0	173,555
2002	)	88,000	0	0	233,373
2003	)	88,000	0	0	199,799
2004	)	88,000	0	7,040	117,773
2005	)	88,000	0	7,040	95,040
2006	)	88,000	0	7,040	95,040
2007	)	88,000	0	7,040	95,040
2008	)	88,000	0	7,040	95,040
2009	)	88,000	0	0	88,000
2010	)	88,000	0	0	88,000
2011	0	88,000	0	0	88,000
2012	0	88,000	0	0	88,000
2013	0	88,000	0	0	88,000
2014	0	88,000	0	0	88,000
2015	0	88,000	0	0	88,000
2016	0	88,000	0	0	88,000
2017	0	88,000	0	0	88,000
Totals	:7	1,584,000	52,148	84,205	2,384,524

Table 4-2 - Annual Soil Generation, Treatment, and End of FY Stockpile (In Tons)

FY	Generated	Treated	EOFY Stockpile
1993	49,005	0	49,005
1994	0	0	49,005
1995	0	0	49,005
1996	12,019	0	61,024
1997	30,234	0	91,258
1998	112,098	109,500	93,856
1999	76,960	109,500	61,316
2000	207,548	109,500	159,364
2001	173,555	109,500	223,419
2002	233,373	109,500	347,292
2003	199,799	109,500	437,591
2004	117,773	109,500	445,864
2005	95,040	109,500	431,404
2006	95,040	109,500	416,944
2007	95,040	109,500	402,484
2008	95,040	109,500	388,024
2009	88,000	109,500	366,524
2010	88,000	109,500	345,024
2011	88,000	109,500	323,251
2012	88,000	109,500	302,024
2013	88,000	109,500	280,524
2014	88,000	109,500	259,024
2015	88,000	109,500	237,524
2016	88,000	109,500	216,024
2017	88,000	109,500	194,524



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	OU TOTAL
OU-1	0	0	0	6336	0	40246	35631	97471	53485	145373	111799	22733	0	0	0	0	0	0	0	0	0	0	0	0	0	513,074
OU-2	0	0	0	3696	22286	59104	31066	12476	22469	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151,096
OU-3	0	0	0	0	0	0	0	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000	1,584,000
OU-4	0	0	0	1987	7948	12748	10263	9601	9601	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52,148
OU-5	49005	0	0	0	0	0	0	0	0	0	0	3960	3960	3960	3960	3960	0	0	0	0	0	0	0	0	0	84,205
FY TOTAL	49005	0	0	12019	30234	112098	76960	207548	173555	233373	199799	117773	95040	95040	95040	95040	88000	88000	88000	88000	88000	88000	88000	88000	88000	2,384,524

(All quantities in tons)

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Figure 4-1 - Soil Excavation and Processing

Figure 4-2 shows that current OU remediation schedules result in the amount of contaminated soils excavated in FYs 1998 and 2000 through 2004 exceeding the annual treatment capacity of the 20 ton/hour system. This is primarily due to the current remediation schedules of OUs 1 and 3.

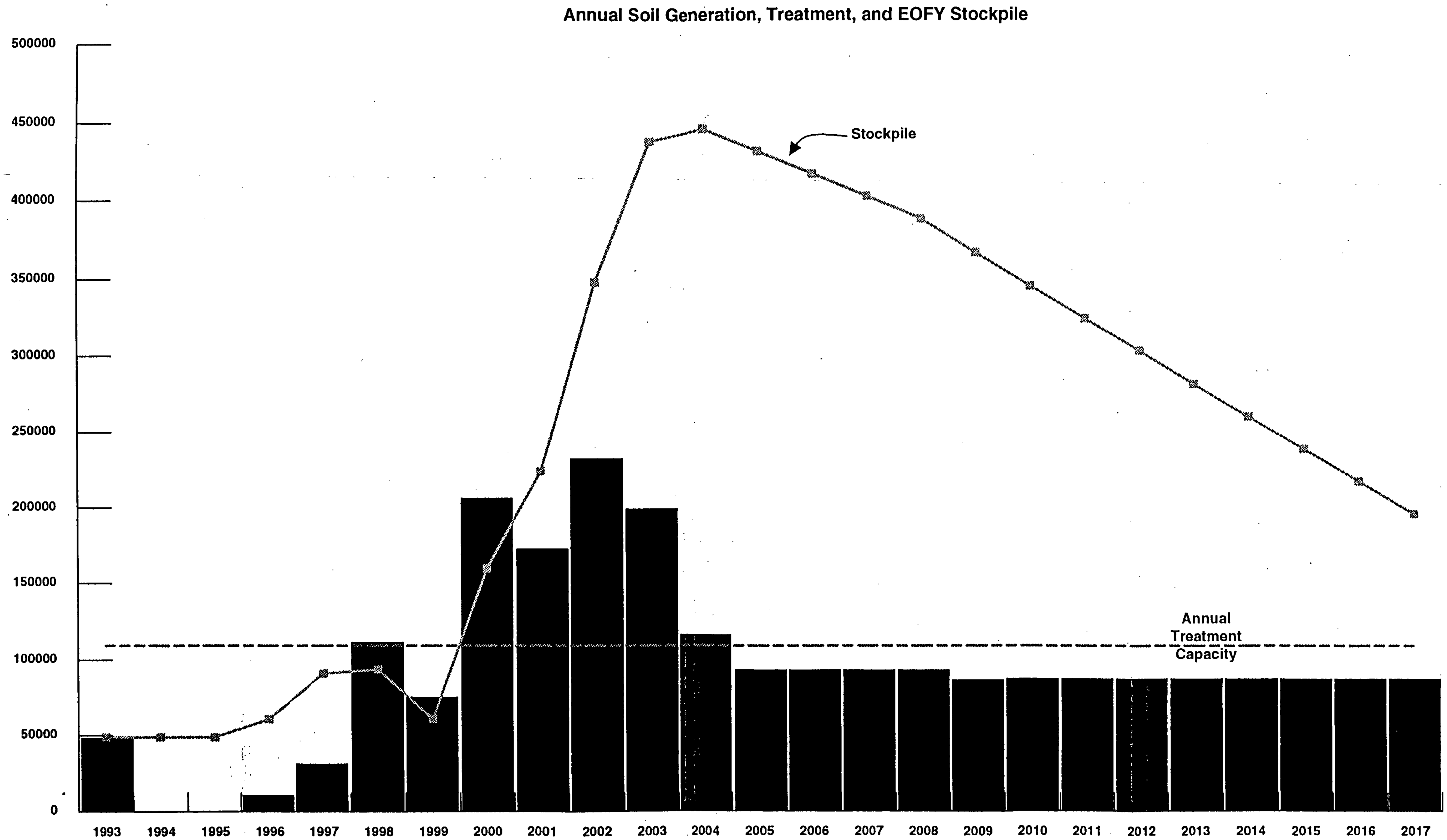

Figure 4-2 - Annual Contaminated Soil Generation

SECTION 5

RECOMMENDED SITEWIDE SOIL REMEDIATION STRATEGY

Several variables must be considered when developing an optimized sitewide soil remediation strategy. The primary variables are:

1) The capacity of the soil treatment system
2) The operating life of the soil treatment system
3) The size of the soil stockpile
4) The quantity of soil excavated annually

5.1 Treatment System Capacity

The largest commercially available soil washing systems are typically rated at 20 ton/hour capacity. On average, the soil washing system will have to process 119,498 tons of contaminated soil per year during a 20-year period. This equates to a nominal processing capacity of 13.64 tons/hour and a rated capacity of 21 tons/hour.

A 20-ton/hour system will be adequate if an on-stream factor of 91 percent can be maintained. This high on-stream factor may be achieved if the system is operated during holidays and adequate spares are maintained to reduce unscheduled downtime.

5.2 Operating Life

Assuming the composite processing factor is maintained at 62.5 percent, the 20 tons/hour soil washing system will have to operate for approximately 21 years, 2 months to treat the quantity of contaminated soil estimated to be generated by the OUs.

5.3 Soil Stockpile Size

Based on current OU remediation schedules, and a 20-ton/hour soil treatment capacity, the contaminated soil stockpile will peak at 445,864 tons in FY 2004. This mass equates to 277,795 CY of ex situ contaminated soil, requiring storage capacity equal to approximately 21 CSFs.

The Removal Action 17 CSF will have a storage capacity of approximately 13,500 CY for soil contaminated with U-total greater than 100 pCi/g. If loose, stock-piled soil is assumed to have a density factor of 1.35 tons/CY, the CSF capacity equates to approximately 18,225 tons. Engineering studies have not estimated the quantity of contaminated soil exceeding 100 pCi/g U-total. For the purpose of this study, it is assumed all contaminated soil will be stored in the CSF. If the soil stockpile size is limited to the storage capacity of the CSF, some type of interim soil treatment will be required to reduce the existing soil stockpile. Table 5-1 illustrates that using current remediation schedules, the treatment system capacity will have to vary between 14 tons/hour and 42 tons/hour to avoid exceeding the storage capacity of the CSF. It would not be cost effective to vary the treatment system capacity because of the high capital costs of the treatment system equipment.

5.4 Soil Excavation Schedules

If the treatment system capacity remains constant at 20 tons/hour, and the soil stockpile size is limited to 13,500 CY (18,225 tons), the quantity of soil excavated annually must be controlled. As a result, current OU remediation schedules will have to be revised.

As shown in Figure 4-2, current OU remediation schedules result in the amount of contaminated soils excavated in FYs 1998, and 2000 through 2004 exceeding the annual treatment capacity of the 20-ton/hour system. By revising the remediation schedules of OUs 1 and 3, and subsequently the quantity of contaminated soil each OU generates annually, the size of the soil stockpile can be maintained below 18,225 tons.

Table 5-2 presents an optimized soil generation schedule. OUs 1, 3, and 5 remediation schedules were revised to ensure the soil stockpile was maintained below 18,225 tons. The following revisions were made to the current OU remediation schedules:

1) OU-1 remedial activities were rescheduled as shown in Table 5-3. This table shows only one of many possible remediation scenarios. The final OU-1 remediation schedule will be determined by FERMCO CRU-1.

2) D&D of the OU-3 production area facilities is expected to generate small quantities of contaminated soil. These soils are not broken out separately in this study but instead are included in the total OU-3 contaminated soil quantity estimate. In Table 5-2, excavation of OU-3 soils is scheduled from FY 2002 through 2018. The annual soil generation quantities are maximized to ensure that the full processing capacity is maintained while still maintaining the soil stockpile under 18,225 tons.

Table 5-1 - Treatment Capacity vs. Soil Stockpile (All Quantities in Tons)

FY	Soil Generated Annually	Treatment Capacity	Soil Processed	Soil Stockpile
1993	49,005		0	49,005
1994	0		0	49,005
1995	0		0	49,005
1996	12,019		0	61,024
1997	30,234		0	18,225*
1998	112,098	21	114,975	15,348
1999	76,960	14	76,650	15,658
2000	207,548	38	208,050	15,156
2001	173,555	32	175,200	13,511
2002	233,373	42	229,950	16,934
2003	199,799	37	202,575	14,158
2004	117,773	21	114,975	16,956
2005	95,040	18	98,550	13,446
2006	95,040	17	93,075	15,411
2007	95,040	17	93,075	17,376
2008	95,040	18	98,550	13,866
2009	88,000	16	87,600	14,266
2010	88,000	16	87,600	14,666
2011	88,000	16	87,600	15,066
2012	88,000	16	87,600	15,466
2013	88,000	16	87,600	15,866
2014	88,000	16	87,600	16,266
2015	88,000	16	87,600	16,666
2016	88,000	16	87,600	17,066
2017	88,000	16	87,600	17,466

*(13,500 CY)(1.35 ton/CY) = 18,225 tons. Assumes interim treatment is provided to reduce the existing stockpile and treat a portion of the soils generated in FY1997.

Table 5-2 - Optimized Soil Generation Schedule (All Quantities in Tons)

FISCAL YEAR	SOIL GENERATED						SOIL PROCESSED	SOIL STOCKPILE
	OU-1	OU-2	OU-3	OU-4	OU-5	TOTAL		
1993					49005	49005	0	49005
1994						0	0	49005
1995						0	0	49005
1996	6336	3696		1987		12019	0	61024
1997		22286		7948		30234	0	18225*
1998	35846	59104		12748		107698	109500	16423
1999	64749	31066		10263		106078	109500	13001
2000	85967	12476		9601		108044	109500	11545
2001	77430	22469		9601		109500	109500	11545
2002	88717		20423		7040	116180	109500	18225
2003	85755		16705		7040	109500	109500	18225
2004	68274		34186		7040	109500	109500	18225
2005			102460		7040	109500	109500	18225
2006			102460		7040	109500	109500	18225
2007			109500			109500	109500	18225
2008			109500			109500	109500	18225
2009			109500			109500	109500	18225
2010			109500			109500	109500	18225
2011			109500			109500	109500	18225
2012			109500			109500	109500	18225
2013			109500			109500	109500	18225
2014			109500			109500	109500	18225
2015			109500			109500	109500	18225
2016			109500			109500	109500	18225
2017			109500			109500	109500	18225
2018			103266			103266	109500	11991
2019							11991	0
TOTALS	513074	151097	1584000	52148	84205	2384524		

* (13,500 CY)(1.35 Ton/CY) = 18,225 Tons. Assumes interim treatment is provided to reduce the existing stockpile and treat a portion of the soils generated in FY 1997.

Table 5-3 - Revised OU-1 Remediation Schedule (All Quantities In Tons)

Fiscal Year	Remedial Activity	Soil Generated	Fiscal Year Total
1996	Pit 6	6,336	6,336
1997	None		0
1998	Pit 1 Cap	2,992	
1998	Pit 5	32,854	35,846
1999	Pit 2 Cap	7,392	
1999	Pit 1 Liner	32,032	
1999	Pit 1 Area Soils	25,325	64,749
2000	Pit 2 Liner	15,840	
2000	Pit 2 Area Soils	16,799	
2000	Burn Pit	53,328	85,967
2001	Pit 3 Cap	38,870	
2001	Burn Pit Area Soils	38,560	77,430
2002	Pit 3 Cap	63,021	
2002	Pit 4 Cap	25,696	88,717
2003	Pit 3 Cap	63,022	
2003	Pit 4 Liner	5,456	
2003	Pit 4 Area Soils	17,277	85,755
2004	Pit 3 Liner	17,072	
2004	Pit 3 Area Soils	51,202	68,274
Total			513,074

3) OU-5 contaminated soils are primarily located adjacent to the OU-3 production area. As a result, they will probably be excavated when the adjacent OU-3 soils are excavated. In Table 5-2 the OU-5 soils are shown excavated in equal amounts between FYs 2002 and 2006.

4) The operating period of the soil washing system is extended an additional 2 years to FY2019. In FY2019, the soil washing system will only operate until the EOFY2018 stockpile is eliminated.

FERMCO CRU-5 is responsible for all of the production area soils remaining after the D&D of the production area facilities, as well as the contaminated soils adjacent to the production area. In addition, CRU-5 is responsible for the soil treatment facility. As a result, FERMCO CRU-5 will determine the optimum excavation schedule for more than 71 percent of the estimated contaminated soils at the FEMP.

SECTION 6

REFERENCES

(DOE 1992a) United States Department of Energy, August 1992. *Treatability Study Work Plan for Operable Unit 5 Soil Washing*. DOE: Fernald Field Office.

(DOE 1992b) ----------, January 1992. *Initial Screening of Alternatives For Operable Unit 5*. DOE: Fernald Field Office.

(DOE 1993a) ----------, May 1993. *Operable Unit 3 Work Plan Addendum, Revision 3*. DOE: Fernald Field Office.

(DOE 1993b) ----------, January 15, 1993. *Facility Utilization Report*. DOE: Fernald Field Office.

(DOE 1993c) ----------, September 1993. *Feasibility Study Report for Operable Unit 4*. DOE: Fernald Field Office.

(FERMCO 1993) Clauss, Lloyd, July 19, 1993. FERMCO Letter to Distribution. Subject: Integrated Site Master Schedule (Rebaselining Effort). FERMCO #: M:PCC:93-0297.

(PARSONS 1993a) PARSONS ERA Project, June 1993. *Functional Requirements Document for a Cover System for the Soil and Rubble Pile North of Third Street, Revision A*. PARSONS: Fairfield.

(PARSONS 1993b) --------, November 1993. *Soil Characterization and Quantification Study, Draft, Revision D*. PARSONS: Fairfield.

(PARSONS 1992) Harvey, B. F., September 30, 1992. PARSONS Letter to D. Brettschneider. Subject: Enhanced Cost Study for Soil Remediation at the FEMP. PARSONS ID#: P-H-OU5A-063.

APPENDIX A

PARSONS MEETING MINUTES

PARSONS
ERA PROJECT

MEETING MINUTES

Date: August 9, 1993
Page: 1 of 4
PARSONS ID#: 05:081:100:0652-93

SUBJECT OF MEETINGS: Preliminary Soil Remediation Integration Meetings

RELATED PROJECT ORDER: PO-81, CDR for OU-5 Soil Remediation

DATE OF MEETINGS: August 3 - 4, 1993

LOCATION: VARIOUS

ATTENDEES:

FERMCO	PARSONS
D. Brettschneider	~~R. Brettin~~
B. Crapse	R. Chernikoff
D. Gerrick	
R. Heath	
G. Jones	
J. Krieger	
T. McClamroch	
B. Tope	
J. Wellinghoff	

PURPOSE: To establish the groundwork for future soil remediation integration meetings.

DISCUSSIONS:

Over the course of two days, PARSONS and FERMCO CRU-5 met with representatives from each FERMCO CRU to discuss the schedule and scope of soil remediation for each OU.

On August 3, 1993, at 10:00 a.m., PARSONS and D. Gerrick of FERMCO CRU-5, met with B. Crapse, G. Jones and J. Wellinghoff of FERMCO CRU-2. At 1:00 p.m., PARSONS and D. Gerrick met with J. Krieger and T. McClamroch of FERMCO CRU-3.

On August 4, 1993, at 10:00 a.m., PARSONS and B. Tope of FERMCO CRU-4, held a telecon with D. Gerrick and D. Brettschneider of FERMCO CRU-5. At 3:00 p.m., PARSONS and D. Gerrick met with R. Heath of FERMCO CRU-1.

FERMCO CRU-3 is using the soil volume estimates prepared by PARSONS as part of the Enhanced Cost Study for Soil Remediation at the FEMP (PARSONS Letter P-H-OU5A-063, dated September 30, 1993). FERMCO CRU-3 has not prepared an independent soil volume estimate. All soils within the boundaries of OU-3 are now the responsibility of FERMCO CRU-5. The exception is those soils excavated in the process of demolishing building foundations. For the purpose of the SCQS, PARSONS will assume building foundations will be excavated 1 year after the building is demolished. PARSONS will level-load the OU-3 soils in the site-wide soil remediation schedule.

FERMCO CRU-4 expects there will be high levels of Lead and Radium contamination in the silo berms. FERMCO CRU-4 has prepared a table of estimated waste volumes as part of the OU-4 Feasibility Study. FERMCO CRU-4 estimates approximately 30,000 cubic yards of soil will require treatment. FERMCO CRU-4 assumes all the K-65 silo berm soils will require treatment. All the soils within 5 feet of the other silos are assumed to require treatment. FERMCO CRU-4 expects that some OU-4 soils will have to be stored on-site awaiting the start-up of the soil washing system.

FERMCO CRU-1 has prepared estimates of the volume of OU-1 soils requiring treatment. These estimates range between 200,000 and 700,000 cubic yards. FERMCO CRU-1 is assuming the waste pit soil liners, and 3 feet of soil under the liners, will require treatment. FERMCO CRU-1 plans to accomplish soil borings around the waste pits this year.

AGREEMENTS: None.

TRANSMITTALS: Table - OU-2 Waste Volumes.

Richard W. Brettin, Project Engineer, CRU-5

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APPENDIX B

FERMCO LETTER M:CRU3:93-0511

6376

FERMCO
Restoration Management Corporation

INTEROFFICE MEMORANDUM

To:	Dennis Beissel	Date:	July 23, 1993
Location:	T-77	Reference:	
From:	Jerry Krieger	FERMCO #:	M:CRU3:93-0511
Location:	T-76, MS 76	Client:	DOE DE-AC05-92OR21972
Extension:	738-8659	Subject:	CERCLA/RCRA Unit 1 Concurrence of Waste Volume Estimates

c:

Hontas Bailey	Stace Dahl	Troy McClamroch
Phil Beirne	Erich Evered	Jerry McGuire
Art Bomberger	Rick Heath	Frank Peters
Terry Borgman	Fred Jebens	Wilf Pickles
Brad Catanach	Jim King	Bill Zebick
Todd Clark	George Latulippe	CRU3 Project Files

Attached are the volume estimates for CERCLA/RCRA Unit 1 (CRU1) potentially contaminated wastes based on the best available information as of June 30, 1993. The estimates provided are for in-place volumes and, in general, are not equal to the volumes of materials that might occur because of the types of treatments, packaging, and associated bulking factors resulting from the remediation efforts. If this attachment changes in any way due to further studies, this information must be passed along to me in order that I may keep an up to date file. It is my intention, however, to check with you on at least a quarterly basis to obtain any new or relevant information.

Please indicate your concurrence with the CERCLA/RCRA Unit 1 in-place waste volume estimates and agreement to provide updated waste volume estimates to me.

If you have any questions concerning this matter, please contact me at 738-8659.

Concurrence: Dennis Beissel   Date: 8/4/93

Dennis Beissel, Director
CERCLA/RCRA Unit 1

TJM:GJK:wjw
Attachments

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TABLE OU-1
Estimate of In Situ Quantities
Operable Unit 1

MATERIAL	VOLUME[a] Cubic Yards (yd^3)	VOLUME[a] Cubic Meters (m^3)	DENSITY[b,c] Tons / yd^3	DENSITY[b,c] Metric Tons/m^3	WEIGHT Tons	WEIGHT Metric Tons	COMMENTS
Pit 1							
Pit 1 cap, clean fraction after soil washing	1,360	1,040	1.35	1.60	1,836	1,665	No shipment off-site, backfill on-site
Pit 1 cap, residual after soil washing	340	260	1.35	1.60	459	416	
Pit 1 sludge	48,500	37,083	1.62	1.92	78,570	71,271	
Pit 1 liner, clean fraction after soil washing	9,100	6,958	1.35	1.60	12,285	11,144	No shipment off-site, backfill on-site
Pit 1 liner, residual after soil washing	9,100	6,958	1.35	1.60	12,285	11,144	
Subtotals	68,400	52,299			105,435	95,640	
Pit 2							
Pit 2 cap, clean fraction after soil washing	3,360	2,569	1.35	1.60	4,536	4,115	No shipment off-site, backfill on-site
Pit 2 cap, residual after soil washing	840	642	1.35	1.60	1,134	1,029	
Pit 2 sludge	24,200	18,503	1.62	1.92	39,204	35,562	
Pit 2 liner, clean fraction after soil washing	4,500	3,441	1.35	1.60	6,075	5,511	No shipment off-site, backfill on-site
Pit 2 liner, residual after soil washing	4,500	3,441	1.35	1.60	6,075	5,511	
Subtotals	37,400	28,596			57,024	51,726	
Pit 3							
Pit 3 cap, clean fraction after soil washing	74,960	57,314	1.35	1.60	101,196	91,795	No shipment off-site, backfill on-site
Pit 3 cap, residual after soil washing	18,740	14,329	1.35	1.60	25,299	22,949	
Pit 3 sludge	204,100	156,055	1.45	1.72	295,945	268,452	
Pit 3 liner, clean fraction after soil washing	4,850	3,708	1.35	1.60	6,548	5,939	No shipment off-site, backfill on-site
Pit 3 liner, residual after soil washing	4,850	3,708	1.35	1.60	6,548	5,939	
Subtotals	307,500	235,115			435,535	395,074	

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TABLE OU-1
Estimate of In Situ Quantities
Operable Unit 1

MATERIAL	VOLUME[a]		DENSITY[b, c]		WEIGHT		COMMENTS
	Cubic Yards (yd^3)	Cubic Meters (m^3)	Tons / yd^3	Metric Tons/m^3	Tons	Metric Tons	
Pit 4							
Pit 4 cap, clean fraction after soil washing	11,680	8,931	1.35	1.60	15,768	14,303	No shipment off-site, backfill on-site
Pit 4 cap, residual after soil washing	2,920	2,233	1.35	1.60	3,942	3,576	
Pit 4 sludge	55,100	42,129	1.62	1.92	89,262	80,970	
Pit 4 liner, clean fraction after soil washing	1,550	1,185	1.35	1.60	2,093	1,898	No shipment off-site, backfill on-site
Pit 4 liner, residual after soil washing	1,550	1,185	1.35	1.60	2,093	1,898	
Subtotals	72,800	55,663			113,157	102,645	
Pit 5							
Pit 5 sludge	97,900	74,854	1.20	1.42	117,480	106,566	
Pit 6							
Pit 6 sludge	9,600	7,340	1.20	1.42	11,520	10,450	
Clearwell							
Clearwell sludge	3,700	2,829	1.20	1.42	4,440	4,028	
Clearwell liner	600	459	1.35	1.60	810	735	
Subtotals	4,300	3,288			5,250	4,762	
Burn Pit							
Burn pit contaminated soil, clean fraction after soil washing	15,150	11,584	1.62	1.92	24,543	22,263	No shipment off-site, backfill on-site
Burn pit contaminated soil, residual after soil washing	15,150	11,584	1.62	1.92	24,543	22,263	
Subtotals	30,300	23,167			49,086	44,526	

TABLE OU-1
Estimate of In Situ Quantities
Operable Unit 1

MATERIAL	VOLUME[a]		DENSITY[b,c]		WEIGHT		COMMENTS
	Cubic Yards (yd^3)	Cubic Meters (m^3)	Tons / yd^3	Metric Tons/m^3	Tons	Metric Tons	
Contaminated Soil (3' average depth under pits)							
Soil, OU1 pit area; clean fraction after soil washing	88,000	67,285	1.35	1.60	118,800	107,763	No shipment off-site, backfill on-site
Soil, OU1 pit area; residual after soil washing	22,000	16,821	1.35	1.60	29,700	26,941	
Subtotals	110,000	84,106			148,500	134,704	
Totals (All Materials)	738,200	564,428			1,042,987	946,094	

References and Notes:

a. Parsons ERA Project PO-10 draft, July 1993, Waste Pit Contents Study Report

b. Parsons ERA Project PO-08, Nov. 1991, Materials Handling Study For the Engineered Treatment, Packaging & Staging Facility, Vol. 2 of 3, Appendix D, Table D-11

c. Estimated dry density.

APPENDIX C

FERMCO LETTER M:CRU2:93-0246

Fernald Environmental
FERMCO
Restoration Management Corporation

INTEROFFICE MEMORANDUM

To:	Ken Kepler	Date:	July 20, 1993
Location:	T-25	Reference:	
From:	Greg Jones	FERMCO #:	M:CRU2:93-0246
Location:	T-78	Client:	DOE DE-AC05-92OR21972
Extension:	6133	Subject:	CRU2 Waste Volumes

c: File Record Storage Copy 106.4.6.7
S. Garland
J. Marsh
W. Morris

The attached table presents the most current CRU2 estimate of waste volumes associated with each of the CRU2 subunits. Please use these volumes in any ongoing cost estimates in lieu of any earlier volume calculations.

GNJ
Attachment

Operable Unit 2 – Waste Volumes

Waste	Type	Probable Destination: Quantity Onsite (cu.yds)	Probable Destination: Quantity Offsite (cu.yds)	Disposition	Calculation
Active Fly Ash Pile					
Fly Ash	Residual or Nontoxic	69,000		Capped in place	61, 250 cy between '52 & '92 topos, 69,000 cy Parsons CDR
In-situ Soil: Clean Fraction after Soil Washing	Solid or Residual	2,850		Soil washed by OU 5; returned for capping in place	95,650 sq.ft x 1 ft deep x 80%
In-situ Soil: Residual after Soil Washing	Haz. or Solid		700	Soil washed by OU 5; transported to offsite disposal	95,650 sq.ft x 1 ft deep x 20%
Inactive Fly Ash Pile					
1' Cover Material: Clean Fraction after Soil Washing	Solid or Residual	4,100		Soil washed by OU 5; returned for capping	138,078 sq.ft. x 1 ft deep x 80%
1' Cover Material: Residual after Soil Washing	Haz. or Solid		1,000	Soil washed by OU 5; pulse dry; dispose offsite	138,078 sq.ft. x 1 ft deep x 20%
Next 3' Cover: Clean Fraction after Soil Washing	Solid or Residual	12,250		Soil Wash (CRU 2 Responsible); Placed under cap	138,078 sq ft. x 3 ft deep x 80%
Next 3' Cover: Residual after Soil Washing	Haz. or Solid		3,050	Soil Wash (CRU 2 Responsible); pulse dry, dispose offsite	138,078 sq.ft. x 3 ft deep x 20%
Fly Ash	Residual or Nontoxic	61,450		Placed in South Field and capped	Volume between '52 and '92 topos minus upper 4 feet
Unwashable Material	Haz. or Solid		2,000	Pulse dried and transported offsite for disposal	Based on existence of contaminated ground water.
Around Unwashable: Clean Fraction after Soil Washing	Solid or Residual	4,000		Soil Wash (CRU 2 Responsible); Placed under cap	Based on existence of contaminated ground water; 80%
Around Unwashable: Residual after Soil Washing	Haz. or Solid		1,000	Soil Wash (CRU 2 Responsible); pulse dry, dispose offsite	Based on existence of contaminated ground water; 20%
Lime Sludge Ponds					
Sludge	Residual or Nontoxic	19,700		In Situ Stabilization; cap in place	N:150'x250'x7'; S:150'x250'x11.5'; Bottom slopes subtracted
In-situ Soil: Clean Fraction after Soil Washing	Solid or Residual	3,100		Soil washed by OU 5; returned for capping in place	Approx. 300 ft long by 350 ft wide x 80%
In-situ Soil: Residual after Soil Washing	Haz. or Solid		800	Soil washed by OU 5; transported to offsite disposal	Approx. 300 ft long by 350 ft wide x 20%
Solid Waste Landfill					
Top 1 ft: Clean Fraction after Soil Washing	Solid or Residual	1,950		Soil washed by OU 5; returned for capping in place	1.5 Acres x 1 ft x 80%
Top 1 ft: Residual after Soil Washing	Haz. or Solid		500	Soil washed by OU 5; transported to offsite disposal	1.5 Acres x 1 ft x 20%
Unwashable Material	Haz. or Solid		750	Pulse dried and transported offsite for disposal	Estimated hot spot volume
Around Unwashable: Clean Fraction after Soil Washing	Solid or Residual	1,400		Soil Wash (CRU 2 Responsible); Placed under cap	1755 cu.yd. x 80%
Around Unwashable: Residual after Soil Washing	Haz. or Solid		350	Soil Wash (CRU 2 Responsible), pulse dry, dispose offsite	1755 cu yd. x 20%
Remaining Waste Material	Residual or Nontoxic	92,500		Capped in place	Volume between '52 and '92 topos, w/o top 1 ft
South Field					
Top 1 ft: Clean Fraction after Soil Washing	Solid or Residual	15,450		Soil washed by OU 5; returned for capping in place	522,250 sq ft. x 1.0 ft deep x 80%
Top 1 ft: Residual after Soil Washing	Haz. or Solid		3,850	Soil washed by OU 5, transported to offsite disposal	522,250 sq ft. x 1.0 ft deep x 20%
Next 0.75 ft: Clean Fraction after Soil Washing	Solid or Residual	11,600		Soil Wash (CRU 2 Responsible), Placed under cap	522,250 sq ft. x 0.75 ft deep x 80%
Next 0.75 ft: Residual after Soil Washing	Haz. or Solid		2,900	Soil Wash (CRU 2 Responsible), pulse dry, dispose offsite	522,250 sq ft. x 0.75 ft deep x 20%
Unwashable Material	Haz. or Solid		10,000	Pulse dried and transported offsite for disposal	Estimated hot spot volume
Around Unwashable: Clean Fraction after Soil Washing	Solid or Residual	12,000		Soil Wash (CRU 2 Responsible), Placed under cap	Estimated Volume surrounding hot spots x 80%
Around Unwashable: Residual after Soil Washing	Haz. or Solid		3,000	Soil Wash (CRU 2 Responsible), pulse dry, dispose offsite	Estimated Volume surrounding hot spots x 20%
OU 2 Totals					
	Residual or Nontoxic	242,650			
	Solid or Residual	68,700			
	Haz. or Solid		29,900		

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20-Jul-93

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APPENDIX D

ANNUAL CONTAMINATED SOIL EXCAVATION BY OU AND ELEMENT

ANNUAL CONTAMINATED SOIL EXCAVATION BY OU AND ELEMENT

FY	OU-1 ELEMENT	OU-1 CY	OU-1 TONS	OU-2 ELEMENT	OU-2 CY	OU-2 TONS	OU-3 ELEMENT	OU-3 CY	OU-3 TONS	OU-4 ELEMENT	OU-4 CY	OU-4 TONS	OU-5 ELEMENT	OU-5 CY	OU-5 TONS	ANNUAL TOTALS CY	ANNUAL TOTALS TONS
1993													Existing Stockpiles	36300	49005	36300	49005
1994																0	0
1995																0	0
1996	Pit 6	3600	6336	Solid Waste Landfill	2100	3696				Berm Soils	1129	1987					
	Subtotal	3600	6336	Subtotal	2100	3696				Subtotal	1129	1987				6829	12019
1997				Solid Waste Landfill	2100	3696				Berm Soils	4516	7948					
				South Field	10563	18590											
				Subtotal	12663	22286				Subtotal	4516	7948				17179	30234
1998	Pit 2 Cap	4200	7392	Inactive Flyash Pile	5907	10396				Berm Soils	4516	7948					
	Pit 5	18667	32854	South Field	12675	22308				Subsurface Soils	2092	3682					
				South Field Hot Spots	15000	26400				Surface Soils	635	1118					
	Subtotal	22867	40246	Subtotal	33582	59104				Subtotal	7243	12748				63692	112098
1999	Pit 1 Cap	1700	2992	Inactive Flyash Pile	7088	12476				Berm Soils	376	662					
	Pit 2 Liner	9000	15840	South Field	10563	18590				Subsurface Soils	4185	7366					
	Pit 2 Area Soils	9545	16799							Surface Soils	1270	2235					
	Subtotal	20245	35631	Subtotal	17651	31066				Subtotal	5831	10263				43727	76960
2000	Pit 1 Liner	18200	32032	Inactive Flyash Pile	7088	12476	Process Area Soils	50000	88000	Subsurface Soils	4185	7366					
	Pit 1 Area Soils	14389	25325							Surface Soils	1270	2235					
	Pit 3 Cap	22792	40114														
	Subtotal	55381	97471	Subtotal	7088	12476	Subtotal	50000	88000	Subtotal	5455	9601				117924	207548
2001	Pit 3 Cap	30389	53485	Inactive Flyash Pile	5316	9357	Process Area Soils	50000	88000	Subsurface Soils	4185	7366					
				Active Flyash Pile	3550	6248				Surface Soils	1270	2235					
				Lime Sludge Ponds	3900	6864											
	Subtotal	30389	53485	Subtotal	12766	22469	Subtotal	50000	88000	Subtotal	5455	9601				98610	173555
2002	Burn Pit	30300	53328				Process Area Soils	50000	88000								
	Burn Pit Area Soils	21909	38560														
	Pit 3 Cap	30389	53485														
	Subtotal	82598	145373				Subtotal	50000	88000							132598	233373
2003	Pit 3 Cap	10130	17829				Process Area Soils	50000	88000								
	Pit 3 Liner	9700	17072														
	Pit 3 Area Soils	29092	51202														
	Pit 4 Cap	14600	25696														
	Subtotal	63522	111799				Subtotal	50000	88000							113522	199799
2004	Pit 4 Liner	3100	5456				Process Area Soils	50000	88000				Soils Outside OU-3	4000	7040		
	Pit 4 Area Soils	12798	17277														
	Subtotal	15898	22733				Subtotal	50000	88000				Subtotal	4000	7040	69898	117773
2005							Process Area Soils	50000	88000				Soils Outside OU-3	4000	7040	54000	95040
2006							Process Area Soils	50000	88000				Soils Outside OU-3	4000	7040	54000	95040
2007							Process Area Soils	50000	88000				Soils Outside OU-3	4000	7040	54000	95040
2008							Process Area Soils	50000	88000				Soils Outside OU-3	4000	7040	54000	95040
2009							Process Area Soils	50000	88000							50000	88000
2010							Process Area Soils	50000	88000							50000	88000
2011							Process Area Soils	50000	88000							50000	88000
2012							Process Area Soils	50000	88000							50000	88000
2013							Process Area Soils	50000	88000							50000	88000
2014							Process Area Soils	50000	88000							50000	88000
2015							Process Area Soils	50000	88000							50000	88000
2016							Process Area Soils	50000	88000							50000	88000
2017							Process Area Soils	50000	88000							50000	88000
TOTALS		294500	513074		85850	151097		900000	1584000		29629	52148		56300	84205	1366279	2384524

ATTACHMENT E

TECHNICAL EVALUATION

6376

Technical Evaluation Report for the Site Integrated Soil Washing Facility

Operable Unit 5
Project Order 81
November 1993
Revision A

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio
FERMCO Subcontract No. 2-21487

PARSONS

Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

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6376

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PARSONS

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6120 South Gilmore Road
Fairfield, Ohio 45014

Technical Evaluation for the Site Integrated Soil Washing Facility

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LIST OF ILLUSTRATIONS (Continued)

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LIST OF ACRONYMS AND ABBREVIATIONS

AWWT	Advanced Wastewater Treatment
C	Celsius
CBD	Sodium citrate/sodium bicarbonate/sodium dithionate
CDR	Conceptual Design Report
CSF	Central Storage Facility
DOE	United States Department of Energy
FEMP	Fernald Environmental Management Project
IC	Ion Chromatography
ID	Integrated Demonstration
IT	International Technology Corporation
MAWS	Minimum Additive Waste Stabilization
ORNL	Oak Ridge National Laboratories
OU	Operable Unit
rpm	revolutions per minute
SCB	Sodium carbonate/bicarbonate
TCLP	Toxicity Characteristic Leaching Procedure

SECTION 1

INTRODUCTION

This Technical Evaluation Report presents the results of preliminary engineering studies performed by PARSONS in support of the Conceptual Design Report (CDR) for Operable Unit 5 (OU-5) Soil Remediation.

This section provides project background information and an overview of the objective and scope of the Technical Evaluation.

1.1 Objective

During approximately 38 years of uranium refinery operations (1951 - 1989), Fernald Environmental Management Project (FEMP) site soils received varying levels of contamination from airborne deposition. In addition, leaks and spills from processing activities within the former production area have resulted in soil contamination. FEMP soils contain inorganic contaminants, including radionuclides and metals, as well as organics.

The *Initial Screening of Alternatives for Operable Unit 5* (DOE 1992a) identified several technologies and process options considered potentially applicable for the remediation of FEMP soils. Among the treatment processes considered was soil washing. Soil washing is an ex situ treatment process employing both physical separation and chemical extraction steps to separate the contaminant from the soil matrix.

Fernald Environmental Restoration Management Corporation proposes to construct a soil washing facility which will treat contaminated soil from all the FEMP OUs. Contaminated soils will be excavated, transported to the treatment facility, treated for the removal of contaminants, and stored temporarily until they are reused at the FEMP (e.g., for unclassified backfill).

Under Project Order 81, PARSONS was tasked with preparing a CDR for the OU-5 soil remediation project. United States Department of Energy (DOE) Order 4700.1 requires that project scoping studies and technical alternative evaluations be performed prior to entering the design phase of a project.

1.2 Scope of Evaluation

The primary objective of this Technical Evaluation is to fulfill the DOE Order 4700.1 requirements. The scope of this Technical Evaluation includes, and the report is organized, as follows:

1) Section 2 provides an overview of soil washing technology and its viability for use on FEMP site soils.

2) Section 3 presents a discussion of the three soil washing treatability testing programs currently underway at the FEMP. This section includes a discussion of the preliminary results of these treatability testing programs.

3) Section 4 presents a proposed integrated soil washing process which will form the technical basis for the conceptual design of the OU-5 soil remediation project.

4) Section 5 presents an evaluation of the merits of a centrally located soil washing facility versus a number of portable soil washing systems.

5) Section 6 presents an evaluation of project siting alternatives for a centrally located soil washing facility with respect to utility requirements and material handling related issues.

6) Section 7 presents recommendations and conclusions based on the results presented in Sections 2 through 6.

1.3 Soil Remediation Technology

Soil remediation can be achieved by the application of one or more of the following treatment technologies:

1) Physical separation using hydrocyclones
2) Vapor Extraction
3) Vitrification
4) Incineration
5) Cementation
6) Soil washing using physical and chemical separation

The following subsections briefly discuss the applicability of each of these technologies to soil remediation at the FEMP.

1.3.1 Physical Separation Using Hydrocyclones

In many instances the contaminants in the soil are mostly associated with fine fractions such as clays and can be physically separated by a simple technique involving slurrying followed by hydrocycloning. The hydrocyclone overflow, which is the fine fraction, contains most of the contaminants and needs further treatment for disposal. The cyclone underflow, which is the coarse fraction, is clean soil and can be used as backfill after verification. Test work on remediation of FEMP soils has indicated that contamination is well distributed in all the size fractions above the FERMCO target value of 52 mg/kg natural uranium (roughly equivalent to 35 pCi/g for natural uranium). Therefore, any treatment involving physical separation techniques alone will not be successful for remediation of FEMP soils.

1.3.2 Vapor Extraction

This technique is adaptable to soils contaminated with volatile organic compounds and can be used in situ. Although some soils have minor organic contamination at the FEMP, the major contaminant is uranium with above background levels for other radionuclides and metals. It is obvious that vapor extraction cannot remediate the FEMP soils containing uranium as the major contaminant.

1.3.3 Vitrification

Vitrification is used to stabilize the contaminants of concern in the glass matrix by heating the mixture of soil and necessary additives to high temperatures in a glass melting furnace. Final product of vitrification is glass which is normally very resistant to leaching and is likely to pass the Toxicity Characteristic Leaching Procedure (TCLP) test. However, it is a high temperature process and the overall cost is a major concern in the application of this technology to soil remediation without any pretreatment such as soil washing designed to concentrate the contaminates in a small fraction. Vitrification of concentrated contaminated fraction from soil washing merits consideration and appears to be promising.

1.3.4 Incineration

Application of incineration to soil remediation is not considered promising as the soil, by its very nature, is not combustible and fuel costs are bound to be excessive. Also, the organics, which are combustible and can be destroyed by incineration, are extremely low in the FEMP soils. As such, incineration as a technology of choice for the remediation of the FEMP soil is ruled out.

1.3.5 Cementation

Soil stabilization employing cementation is a viable technology and can be used for the remediation of the FEMP soils based on the results of treatability studies. The major drawback of this process is that it results in a substantial increase (1.5-2 times the original waste volume) in the waste volume and the consequent high disposal costs. It is a relatively simple process based on specific formulations developed during bench scale/pilot plant studies and can be implemented at ambient temperature. A prerequisite for the acceptance of any formulation is that the product of cementation must pass the TCLP test. The processing and disposal costs are expected to be high in case the entire contaminated soil is stabilized by cementation without any pretreatment, such as soil washing, to reduce volume.

As in the case of vitrification, cementation is also considered a viable and attractive technology for the treatment of the contaminated residue of the soil washing process. In view of some problems associated with the product of cementation at Oak Ridge and Rocky Flats, it is recognized that maximum emphasis must be given on rigid process control to ensure a quality product. The technology is reliable and can be implemented without the hazards of high temperature involved in vitrification.

1.3.6 Soil Washing Using Physical and Chemical Separation

Soil washing employing physical and/or chemical separation techniques is applicable for the removal of organics, metals, and radionuclides from contaminated soils. Some full scale soil washing facilities are in operation here and abroad. Bench scale test work on the remediation of the FEMP soils using physical and chemical soil washing techniques has clearly established that these soils can be treated to a target value of <52 mg/kg natural uranium, which is the indicator parameter for contamination at the FEMP. Several leaching agents such as mineral acids, citric acid, and sodium carbonate/bicarbonate (SCB) have been effective in cleaning the FEMP soils. Additional pilot scale work is necessary to optimize the test conditions and establish efficiency of the soil washing process.

It is estimated that the volume of clean soil that could be used as refill could be approximately 70 percent or even higher. Only the concentrated fraction containing contaminants, and the contaminated soil that remains contaminated even after washing will need further treatment for disposal. This can be achieved by employing vitrification or cementation technologies for remediation of the entire FEMP soils but is not considered economical. Soil washing is the obvious technology of choice for remediating the FEMP soils followed by stabilization of contaminated residues of soil washing using vitrification/cementation. Also, the contaminated soil from the soil washing process can be used as a source of silica for the vitrification of sludges at the FEMP.

SECTION 2

SOIL WASHING OVERVIEW

Soil washing is an ex situ process used for removing contaminants from soil. The process removes contaminants in either of two ways; the contaminants are dissolved or suspended in wash solution, or they are concentrated into a smaller volume of soil by removing clean portions of the soil through particle size separation techniques. Soil washing systems that incorporate a combination of these two techniques offer the greatest promise for treating soils containing a wide range of contaminants (i.e., heavy metals, organics, inorganics, radionuclides, volatile organic compounds, polychlorinated biphenyls, pesticides, etc.).

The concept of separating contaminants from soil by using particle size separation is based on the phenomenon that most of the organic and inorganic contaminants are bound, by chemical or physical means, to the clay and silt soil particles. The silt and clay, in turn, are attached to the coarse sand and gravel particles by physical means, primarily compaction and adhesion. Therefore, separating the fine fraction of the soil from the coarse fraction will effectively separate and concentrate the contaminants into a smaller volume of soil. This reduced volume of soil can be further treated or disposed. The coarse fraction of soil is usually considered non-contaminated, and can be returned to the site for unrestricted use after verification. In general, soil washing is effective on soils containing a large percentage of coarse sand and gravel particles. Soils containing a large percentage of clay and silt particles typically do not respond well to soil washing.

Soil washing has been used as a stand-alone technology or in combination with other treatment technologies. Soil washing can be cost-effective when used as a pre-processing step to reduce the quantity of material to be processed by another technology, such as vitrification or solidification.

Site cleanup objectives and physical and chemical characteristics of the soils and contaminants must be known to estimate the performance of this technology. This information is also used to determine waste preparation and pretreatment requirements.

The key physical parameter that determines the feasibility of the soil washing process is the particle size distribution of the soil to be treated. The particle size distribution may be used as an initial means of screening the potential for using soil washing. Other physical parameters that help determine process feasibility include soil type, physical form, handling properties, and moisture content.

The key chemical parameters that determine the feasibility of the soil washing process are the concentrations and types of contaminants, and their distribution in the soil. Soil washing contaminant removal efficiency depends on the type and distribution of contaminants present in the soil and the soil washing medium. Typically, volatile organics are easily removed by soil washing with removal efficiencies from 90 to 99 percent. Semi-volatile organics are removed by soil washing with removal efficiencies in the range of 40 to 90 percent. Metals and pesticides, which are more soluble in water, often require acids and/or chelating agents to aid their removal.

Complex mixtures of contaminants in the soil (e.g., a mixture of metals, nonvolatile organics, and semivolatile organics) and frequent changes in the contaminant composition in the soil matrix make it difficult to formulate a single suitable washing fluid that will consistently and reliably remove all of the different types of contaminants.

Additives used to enhance the soil washing process, such as surfactants, solvents, and chelating agents may interfere with wastewater treatment processes downstream. The presence of these additives in washed soil may cause some difficulty in treated soil disposal. Costs associated with handling the additives and managing them as part of the residuals and wastewater streams must be weighed against the incremental improvements in soil washing performance that they may provide.

2.1 Technology Description

The overall soil washing process can be divided into three different areas; soil preparation, soil washing, and wastewater treatment.

Soil preparation includes the excavation and/or moving of contaminated soil to the process where it is screened to remove debris and large objects. Here, the soil can be made pumpable by adding water. This depends on soil feed requirements and whether the process is a semi-batch or continuous operation.

Soil washing can involve a number of unit operations. Soil is initially screened to separate the coarse particles from the fines. The coarse particles are usually considered clean and are removed from the process as product; however, this fraction may require treatment, if necessary. The fine soil particles are mixed with wash water (containing extraction agents, if required) to remove contaminants from the soil and transfer them to the wash fluid phase. The soil and wash water are then separated, and the soil is rinsed with clean water. Clean soil is then removed from the process as product. Suspended soil particles are settled from the spent wash water as sludge.

Wastewater is treated by conventional operations such that the treated water can be recycled to the soil washing process for further use. Any wastewater that may be discharged is treated to meet regulatory requirements for heavy metal content, organics, total suspended solids, and other parameters.

Air emissions from soil excavation, feed preparation, and extraction may require collection and treatment before being released to the atmosphere.

SECTION 3

SOIL WASHING TESTING PROGRAMS AT THE FEMP

3.1 OU-5 Treatability Study by IT

The International Technology Corporation (IT) bench scale soil washing study concentrated on removing uranium from FEMP soils through various physical separation, chemical extraction, and combination physical separation/chemical extraction techniques without seriously degrading the soil's physicochemical characteristics, and without generating an excessive secondary waste form that would result in complex treatment, handling, or disposal scenarios.

Two different soil samples from the FEMP were used in the evaluation. One of the soils is from near a waste incinerator area where low-level contaminated trash was burned (Integrated Demonstration [ID]-A), and the other is from near the Plant 1 storage pad (ID-B). The average uranium concentrations in these soils are 497 mg/kg and 450 mg/kg for the ID-A and ID-B soils, respectively. Both soil samples had been pre-sieved before testing through a 19 mm sieve at the site. The target uranium concentration for clean soil used throughout the bench-scale testing is 52 mg/kg of natural uranium.

3.1.1 Physical Separation

The physical separation remedy screening was performed to identify the particle size distribution of the soil itself and to identify the soil size fractions with which the uranium is associated. The study was divided into two separate stages: Stage 1 and Intermediate Stage. Stage 1 and Intermediate Stage are described in the following subsections.

Stage 1

The first step in Stage 1 of remedy screening involved soil sample preparation and initial soil analysis. Part of each soil was dry sieved and separated by the ranges of 19 to 9.5 mm, 9.5 to 2 mm, and < 2 mm, then homogenized. The average radiological activity and uranium concentration for each homogeneous fraction were determined by ion chromatography (IC). The next step in Stage 1 remedy screening involved soil separation according to size fraction by using dispersing agents to break the soil into its individual grains. The soil samples were ultimately dispersed into five distinct size fractions for analysis; 19 to 9.5 mm, 9.5 to 2 mm, 2 mm to 53 μm, 53 to 2 μm, and < 2 μm. A sample of each soil fraction was then subjected to several dispersants including sodium bicarbonate ($NaHCO_3$), sodium hydroxide (NaOH), sodium carbonate (Na_2CO_3), potable water, and sodium citrate/sodium bicarbonate/sodium dithionate (CBD). Each reagent was approximately 1 millimolar in concentration.

The results of using various dispersants on each size fraction of the soil are shown in Table 3-1. The distribution of uranium among each size fraction indicates that simple physical separation, even with a chemical dispersant, does not result in a size fraction with < 52 mg/kg of uranium. However, the use of chemical dispersants decreased the percent sand fraction while increasing the percent silt fraction; and the use of sodium dispersants shifted the major uranium loading from the sand and silt fractions to the clay fraction for both soils.

Intermediate Stage

An Intermediate Stage of testing was incorporated using attrition scrubbing and stronger wash/dispersant solutions on the < 2 mm soil size fraction (divided into < 53 μm and > 53 μm). The remaining parts of each sample were homogenized and labeled "as received." Both samples were tested using four different dispersion/washing agents (Na_2CO_3/$NaHCO_3$, $(NH_4)_2CO_3$/$(NH_4)HCO_3$ sodium pyrophosphate, and tap water), at three different concentrations (0.1 M, 0.25 M, and 0.5 M), and three different contact times (5, 15, and 30 minutes). The carbonates were used because of their previous success, the pyrophosphate as an additional reagent, and the tap water as a control.

For the ID-A soils, a scrubbing time of 30 minutes with an extractant concentration of 0.25 M yielded a 70 percent uranium reduction in the sand fraction for all the extractants used. The optimum conditions appear to be a 0.25 M extractant concentration with a 15-minute scrubbing time. Even though the SCB (0.25 M/15 minutes) yielded the best results for the < 53 μm size fraction (100 mg/kg), this solution also yielded the worst results for the > 53 μm size fraction (786 mg/kg).

For the ID-B soils, the optimum conditions appear to be a 0.25 M extractant concentration with 15 minutes scrubbing time. All extractants were able to get the < 53 μm size fraction down to approximately 150 mg/kg, and the > 53 μm size fraction to between 46 to 85 mg/kg.

Table 3-1 - Particle Size Distribution and Uranium Concentration for the < 2mm ID-A and ID-B Soils as a Result of Water and Different Dispersion Solutions

		Soil Size Fraction (mm)					
		2-0.053		0.053-0.002		<0.002	
Soil Location	1mM Dispersing Agent	Soil Fraction (%)	Uranium Concentration (mg kg^{-1})	Soil Fraction (%)	Uranium Concentration (mg kg^{-1})	Soil Fraction (%)	Uranium Concentration (mg kg^{-1})
ID-A	H_2O	23.3	1970	72.6	340	4.1	883
Incinerator	NaOH	11.6	1566	83.0	265	5.4	1303
Area	Na_2CO_3	9.4	1610	85.8	267	4.8	2017
	$NaHCO_3$	9.3	2202	85.6	300	5.1	1295
	CBD	10.7	1713	78.3	227	11.0	913
ID-B	H_2O	38.4	228	55.1	273	6.5	1219
Plant 1 Pad	NaOH	27.6	231	66.4	270	6.0	2293
Area	Na_2CO_3	28.3	214	67.3	247	4.4	3577
	$NaHCO_3$	27.1	248	68.6	279	4.3	3244
	CBD	28.1	186	56.3	281	15.6	999

[a] Solutions were 1:4 soil:dispersing solution ratios shaken for 30 minutes.

3.1.2 Chemical Extraction

The objective of the chemical extraction remedy screening was to selectively extract uranium from soil without generating an excessive secondary waste form that would require complex treatment, handling, or disposal scenarios. The application of chemical extraction to removing uranium from the FEMP soils is adapted from a process applied in the mining industry where uranium is characteristically leached from uranium ores using acid, carbonate, and alkaline based extractants. The selection of extractants used for testing on the FEMP soils follows this same philosophy, and each extractant was tested for its ability to remove uranium as a function of extraction time, extractant concentration, extraction temperature, and extractant-to-soil ratio. Testing was performed in three separate stages: Stage I, Stage II, and Stage III, with all testing performed on the < 2 mm size fraction of the homogenized soil prepared in the physical separation testing.

Stage I

Stage I testing of viable extraction candidates included 1:1 concentrations of sulfuric, hydrochloric, nitric, and phosphoric acids; 60g/20 liter concentrations of sodium carbonate/sodium bicarbonate and ammonium carbonate/ammonium bicarbonate; 4.0 N concentration of sodium hydroxide; 15 percent concentrations of sodium chloride and potassium chloride; 0.5 M concentration of EDTA; and 1:10 concentrations of NS1 and Citrikleen™. Each extractant was tested at a 10:1 (wt:wt) ratio of extractant to soil, where the extraction process consisted of the soil and extractant mixtures being mechanically stirred for 4 hours at 80 degrees Celsius. Initial IC and gross alpha/beta results indicated that Citrikleen™ would not be an effective extractant, therefore, further testing on Citrikleen™ was not pursued. The EDTA solutions were tested at three different pH values (6, 8, and 10). For a complex mixture of metals, the pH of the solution must be varied to maximize the solubilities of the metals of concern (Dow 1981, 1985). The extracted solids, extractant solution, and rinse water were analyzed for uranium by IC and radiological activity by gross alpha/beta, and the performance of each extractant was evaluated by the calculated percent removal of uranium, and overall decrease in activity in the soil.

The 18N sulfuric acid, 6N hydrochloric acid, and 8N nitric acid extractions were the most successful extracting agents for both the ID-A and ID-B soils (Tables 3-2 and 3-3). All three extractants resulted in extracted solids with uranium concentrations below the 52 mg/kg target limit, and all three extracted uranium with a greater than 95 percent removal efficiency. The high concentrations of the extractants used for the screening process would not be feasible for a full scale application. Therefore, these three extractants were further evaluated in Stage II testing to determine the lowest concentration of each extractant required to reduce the uranium concentration in the extracted solids to < 52 mg/kg of uranium to make the pilot plant economical to operate.

Table 3-2 - Stage I Extractant Screening ID-A Soils

Extractant	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed
0.5M EDTA; pH 6	154.95	55.08
0.5M EDTA; pH 8	64.60	79.68
0.5M EDTA; pH 10	42.27	91.21
Sulfuric Acid; 18N	14.04	96.09
Hydrochloric Acid; 6N	23.37	95.26
Nitric Acid; 8N	4.87	98.93
Phosphoric Acid; 22N	13.09	96.08
Sodium Carb/Bicarb; 0.8M	75.01	87.47
Sodium Hydroxide; 4N	128.31	72.58
Ammonium Carb/Bicarb; 0.8M	106.56	82.71
Sodium Chloride; 15%	329.34	14.31
Potassium Chloride; 15%	380.81	5.10
NS1; 1:10	186.28	65.37
Citrikleen; 1:10	414.04	29.26

Table 3-3 - Stage I Extractant Screening ID-B Soils

Extractant	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed
0.5M EDTA; pH 6	78.13	73.25
0.5M EDTA; pH 8	34.62	85.84
0.5M EDTA; pH 10	24.26	91.66
Sulfuric Acid; 18N	13.41	97.24
Hydrochloric Acid; 6N	3.18	99.24
Nitric Acid; 8N	2.34	99.48
Sodium Carb/Bicarb; 0.8M	25.50	94.85
Sodium Hydroxide; 4N	29.07	91.65
Ammonium Carb/Bicarb; 0.8M	29.07	93.48
Sodium Chloride; 15%	353.51	15.43
Potassium Chloride; 15%	374.16	10.03
NS1; 1:10	54.32	86.99
Citrikleen; 1:10	245.14	46.58

Stage II

Stage II of chemical extraction testing further evaluated the effectiveness of sulfuric, nitric, and hydrochloric acid in removing uranium from contaminated soil. The acids were serially diluted (5 different concentrations each) until they were unable to render the solids < 52 mg/kg uranium (target value). The tests (summarized in Tables 3-4, 3-5, and 3-6) were performed using the same methodologies as in Stage I testing. Stage II testing shows that a minimum of 1.0N concentration of each acid was required to reduce the level of uranium in the ID-A soils to < 52 mg/kg, with the nitric acid extraction giving the best results (98 percent removal @ 1N concentration), leaving only 9.04 mg/kg of uranium in the extracted solids. Also for each acid extraction, no appreciable increase in uranium removal was gained by increasing the acid concentrations above 1.0N. The ID-B soils fared better when using the lower concentration acids (< 1N). A 0.2N H_2SO_4 extraction removed 92.3 percent of uranium, and a 0.5N HNO_3 extraction removed 96.6 percent of uranium from the contaminated soil. However, it is also noted that the lower concentration acid extractions were more difficult to filter. HCl was the least effective extractant at the lower concentrations. For this reason, sulfuric acid and nitric acid were further studied in Stage III testing.

Table 3-4 - Stage II Chemical Extraction H_2SO_4 Screening

Extractant Contamination	ID-A Soils		ID-B Soils	
	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed
0.2N	409.00	1.08	45.70	92.26
1.0N	13.80	97.29	18.40	96.90
2.0N	12.60	97.70	8.59	98.30
12N	8.79	98.53	15.20	97.11
18N	14.04	98.03	13.41	97.31

Table 3-5 - Stage II Chemical Extraction HCI Screening

Extractant Concentration	ID-A Soils		ID-B Soils	
	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed
0.1N	433.00	0.22	176.00	68.35
0.5N	441.00	0.80	145.00	78.11
1.0N	14.20	97.82	8.41	98.81
4N	15.00	97.77	4.70	99.39
6N	23.37	95.55	3.18	99.55

Table 3-6 - Stage II Chemical Extraction HNO_3 Screening

Extractant Concentration	ID-A Soils		ID-B Soils	
	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed	Uranium in Extracted Soil (mg kg^{-1})	% Uranium Removed
0.1N	395.00	4.58	163.00	71.63
0.5N	448.00	2.83	22.80	96.55
1.0N	9.04	98.03	9.81	98.65
5.3N	7.16	98.67	3.56	99.52
8N	4.87	99.27	2.34	99.66

Stage III

Stage III testing thoroughly evaluated the extraction parameters of extraction temperature, extractant concentration, extractant dose (extractant-to-soil ratio), and extraction time. Each parameter was systematically varied during testing, and operating conditions for the extractants were optimized during this stage. The tests were performed in the same equipment and the same basic methodologies were followed as in the two previous stages.

The results of Stage III testing are summarized in Tables 3-7 and 3-8. In the nitric acid extractions of ID-A soil, increasing the extraction temperature from 20 degrees C to 40 degrees C resulted in an average increased uranium removal of 50 mg/kg. Increasing the extractant concentration from 1N to 2N did not seem to enhance uranium removal at 20 degrees C, but it did enhance uranium removal at 40 degrees C. Neither increasing the extraction time from 0.5 to 2 hours, and/or increasing the dose rate from 4:1 to 7:1 had an appreciable impact on uranium removal. In the nitric acid extractions of ID-B soil, the 1N concentration at a 4:1 dose rate was not effective in removing uranium, regardless of extraction temperature or extraction time. The 1N concentration extractions were more effective at the 7:1 dose rates at either temperature. The 2N extraction, however, was very effective for each extraction temperature, extraction time, and dose rate. The best results for the HNO_3 extraction testing for both ID-A and ID-B soils (only 26 and 42 mg/kg of uranium left in extracted solids, respectively) were achieved using a 7:1 dose rate of 1N HNO3 extracted for 0.5 hours at 40 degrees C.

Table 3-7 - Stage III Time, Temperature, and Concentration Study
(mg/kg of uranium in extracted soil)

Dose rate, time	ID-A Soil							
	H_2SO_4				HNO_3			
	1N;20C	1N;40C	2N;20C	2N;40C	1N;20C	1N;40C	2N;20C	2N;40C
4:1, 0.5 hrs	69.86	38.14	62.94	36.07	110.12	44.5	98.91	28.54
7:1, 0.5 hrs	73.7	40.59	48.7	51.66	287.5	26.05	102.9	28.45
4:1, 2 hrs	66.09	38.36	67.61	30.67	106.4	61.53	97.22	30.59
7:1, 2 hrs	93.59	31.28	57.03	27.85	92.5	55.49	95.36	119

Table 3-8 - Stage III Time, Temperature, and Concentration Study
(mg/kg of uranium in extracted soil)

Dose rate, time	ID-B Soil							
	H_2SO_4				HNO_3			
	1N;20C	1N;40C	2N;20C	2N;40C	1N;20C	1N;40C	2N;20C	2N;40C
4:1, 0.5 hrs	68.94	38.82	27.04	27.46	455.03	526.63	39.78	28.76
7:1, 0.5 hrs	30.71	19.85	25.7	24.82	59.63	41.84	482.17	26.08
4:1, 2 hrs	50.12	75.64	32.59	32.98	510.35	468.6	32.37	31.39
7:1, 2 hrs	28.04	25.2	22.89	17.79	38.48	40.22	27.99	17.63

In the sulfuric acid extractions, increasing the extraction temperature from 20 degrees C to 40 degrees C resulted in an average increased uranium removal of 30 mg/kg for the ID-A soil. Increasing the extractant concentration from 1N to 2N did not seem to enhance uranium removal at either 20 degrees C or 40 degrees C. Neither increasing the extraction time from 0.5 to 2 hours, and/or increasing the dose rate from 4:1 to 7:1 had an appreciable impact on uranium removal. The sulfuric acid extractions of ID-B soil (overall) were very effective, regardless of the extraction conditions. The best results for the H_2SO_4 extraction testing for both ID-A and ID-B soils (only 38 and 39 mg/kg of uranium left in extracted solids, respectively) was achieved using a 4:1 dose rate of 1N H_2SO_4 extracted for 0.5 hours at 40 degrees C.

These data show thn with sulfuric acid is very effective in removing uranium from the < 2 mm soil frit the soil can be considered as clean. The data from the physical separation shows th is effective in reducing the level of uranium in the "whole soil," but not to the pointlered as clean. This strongly suggests that employing physical separation techniquxtraction would provide an optimized soil washing process.

3.1.3 Cos

The testing of the crsical separation and chemical extraction) was performed on the FEMP soils in eithried forms. The overall combined process testing was divided into five separate tests were designed to determine the efficiency and order of the combined process. :signed to determine the ability of sand to decrease the buffering effects of clay on al the fifth test was designed to determine if a multiple chemical extraction would seaminants from the soil.

The first test consising followed by chemical extraction, where "as received" soils were attrition scruCO_3/$NaHCO_3$ for 15 minutes, then split into two samples for chemical extractionxtracted at a 4:1 and 7:1 extractant-to-soil ratio dose rate with 1 N sulfuric acid atninutes. This procedure reduced the uranium in the ID-A soils to 42 mg/kg using : first run; however, the second run reduced the uranium in the soil to only 64 mgverage of both runs of approximately 55 mg/kg (Table 3-9). Increasing the dosepreciable effect on uranium removal from the ID-A soil. For ID-B soil, this prociium to approximately 26 and 31 mg/kg for the first and second runs, respectively, Just as with the ID-A soils, increasing the dose rate to 7:1 had no appreciable effe from the ID-B soil. For all cases, a large portion of uranium is removed from thacid extraction stage.

The second test foltions as the first test, except that in the second test, chemical extraction was perf scrubbing. The sample was neutralized with 3 M sodium hydroxide to a pH then 0.1 M sodium carbonate/sodium bicarbonate was added to bring the dry so:1, and the sample was attrition scrubbed as in the first test. Dewatering, splittialso done as in the first test. This procedure proved to be successful only in tA soil, reducing the uranium concentration to 39 mg/kg (Table 3-10). The second runs for the ID-B soil resulted in uranium concentrations above 52 mg/kg. Just asation is made that the largest portion of uranium is removed during the sulfuric aich strongly suggests that attrition scrubbing should be applied as a preparation pranishing process.

Table 3-9 - Test 1 -
Attrition Scrubbing with 0.1M Sodium Carbonate/Bicarbonate
Followed by Chemical Extraction with 2N Sulfuric Acid for 0.5 Hours

Description	ID-A (mg/kg Uranium)		ID-B (mg/kg Uranium)	
	Run 1	Run 2	Run 1	Run 2
Results after Attrition Scrubbing (2:1 Dry Solid to Liquid Ratio)	310.23	372.59	235.82	248.18
Results after Chemical Extraction				
(4:1 Dose Rate, 40 Degrees C)	42.04	63.62	25.57	30.82
(7:1 Dose Rate, 40 Degrees C)	31.28	68.97	22.96	25.68

Table 3-10 - Test 2 -
Chemical Extraction with 2N Sulfuric Acid for 0.5 Hours Followed by
Attrition Scrubbing with 0.1M Sodium Carbonate/Bicarbonate for 0.25 hours

Description	ID-A (mg/kg Uranium)		ID-B (mg/kg Uranium)	
	Run 1	Run 2	Run 1	Run 2
Results after Chemical Extraction				
(4:1 Dose Rate, 40 Degrees C)	101.57	76.15	77.56	77.66
Results after Attrition Scrubbing (2:1 Dose Rate)	39.15	50.49	56.18	55.71

The third test followed the same conditions as the first test, except that water replaced the carbonate/bicarbonate solution during attrition scrubbing. Overall, this procedure was unsuccessful with only the first run of 7:1 extraction of ID-B soil resulting in a <52 mg/kg uranium concentration (Table 3-11). The uranium concentrations resulting after attrition scrubbing with potable water were approximately 20 percent and 50 percent higher for the ID-A and ID-B soils, respectively, when compared to the results from Test 1 where $Na_2CO_3/NaHCO_3$ (SCB) was used as the scrubbing agent. This put a greater load on the chemical extraction stage to remove uranium.

The fourth test involved attrition scrubbing for 15 minutes with the addition of coarse play sand to dry soil and 0.25 M $Na_2CO_3/NaHCO_3$. The sample was wet sieved through a 53 μm sieve, then the solids (both $<$ 53 μm and $>$ 53 μm) and the resulting liquid were submitted for analysis for uranium and gross alpha/beta. This procedure was successful in removing uranium from the >53 μm (sand) soil fraction (<12 mg/kg uranium for both the ID-A and ID-B soils); however, it was not successful for the <53 μm (silt) soil fraction of either ID-A or ID-B soils (Table 3-12).

The fifth test involved a multiple chemical extraction process where each sample was extracted with 1.0 N HCl followed by an extraction with 1.0 M Na_2CO_3/$NaHCO_3$. Four sets of conditions were used:

1) 7:1 extractant-to-soil ratio extracted @ 40 degrees C for 60 minutes
2) 4:1 extractant-to-soil ratio extracted @ 40 degrees C for 60 minutes
3) 7:1 extractant-to-soil ratio extracted @ ambient for 60 minutes
4) 4:1 extractant-to-soil ratio extracted @ ambient for 60 minutes

For the ID-A soil, this procedure proved to be successful for the tests run at 40 degrees C, reducing the uranium concentration to 27 mg/kg for the 4:1 dose rate (Table 3-13); however, it was unsuccessful for the tests run at ambient temperatures for either dose rate. This procedure was successful for all testing parameters for the ID-B soil. The best results (7.7 mg/kg uranium) were achieved using a 4:1 dose rate at a temperature of 40 degrees C. The data show that the target uranium level in the ID-B soils can be reached by using just the HCl extraction (either 4:1 or 7:1 dose rate) at 40 degrees C extraction temperature.

Table 3-11 - Test 3 -
Attrition Scrubbing with Potable Water for 0.25 Hours
Followed by Chemical Extraction with 2N Sulfuric Acid for 0.5 Hours

Description	ID-A (mg/kg Uranium)		ID-B (mg/kg Uranium)	
	Run 1	Run 2	Run 1	Run 2
Results after Attrition Scrubbing (2:1 Dry Solid to Liquid Ratio)	363.14	425.14	347.89	363.63
Results after Chemical Extraction				
(4:1 Dose Rate, 40 Degrees C)	79.49	79.25	76.76	80.62
(7:1 Dose Rate, 40 Degrees C)	64.46	56.99	42.37	70.19

Table 3-12 - Test 4 -
Attrition Scrubbing with Sand and 0.25M Sodium Carbonate/Bicarbonate for 0.25 Hours

Description	ID-A (mg/kg Uranium)		ID-B (mg/kg Uranium)	
	>53 μm	<53 μm	>53 μm	<53 μm
(5:1:2 Dose Rate of Sand:Soil:Fluid)	11.84	88.13	11.18	130.35

Table 3-13 - Test 5 -
Chemical Extraction with 1N Sulfuric Acid for 1 Hour
Followed by Chemical Extraction with 0.8M Sodium Carbonate/Bicarbonate

Description	ID-A (mg/kg Uranium)				ID-B (mg/kg Uranium)			
	4:1, 40°C	7:1, 40°C	4:1, Amb	7:1, Amb	4:1, 40°C	7:1, 40°C	4:1, Amb	7:1, Amb
Results after HCl Extraction	77.03	67.98	94.08	82.92	28.37	20.06	69.64	33.22
Results after SCB Extraction	27.11	38.98	68.32	61.77	7.7	6.71	15.7	13.55

3.2 DOE-FEMP Integrated Demonstration Program Soil Treatability Study by ORNL

The test work completed by Oak Ridge National Laboratories (ORNL) concentrated on the selective leaching of uranium from uranium contaminated soils using sodium carbonate and citric acid; therefore, the characterization data presented by ORNL is generally limited to total uranium analysis. Some leaching tests were conducted using mineral acids. The objective of the testing was to selectively extract uranium using a soil washing/extracting process without significantly degrading the soil's physical or chemical characteristics or generating a secondary waste that would be difficult to manage and/or dispose. This test work is based on the fact that uranium is characteristically leached from uranium ores using acid and carbonate based extractants.

Two soil samples from the FEMP site were treated; one sample was excavated near the Plant 1 storage pad and the second sample was excavated near a waste incinerator that once burned low-level contaminated trash. Each excavated area was about 25 by 20 feet with an excavation depth of 6 to 8 inches. The uranium content in the FEMP soils ranged from 450 to 550 μg of uranium per gram of soil. The methods used to separate particle size fractions were based on wet sieving and centrifugation techniques, and only soils less than 4.75 millimeters were used in the testing.

3.2.1 Leaching Designs

Two leaching designs were used in the ORNL testing; one design incorporated leaching at a low solution-to-soil ratio (1:1) using paddle mixers for attrition and mixing, and the other incorporated leaching at a high solution-to-soil ratio (10:1) using a rotary extractor for mixing.

3.2.1.1 Low Solution-to-Soil Ratio

In the case of low solution-to-soil ratio, most of the leaching tests were conducted using a sodium carbonate solution (25 grams $NaHCO_3$ and 25 grams Na_2CO_3 per liter), and within a pH range of 9.3 to 9.5. Potassium permanganate ($KMnO_4$) was added (0.02 g/g soil) to oxidize any uranium (IV) to the uranium (VI) state to form the stable sodium uranyl tricarbonate complex, $Na_4[UO_2(CO_3)_3]$. The tests were conducted in standard 1-liter glass resin kettles immersed in a temperature controlled water bath. 400 milliliters of sodium carbonate solution were added to 400 grams of soil and agitated. Upon completion of the leaching, the suspension was filtered through Whatman 40 paper filter. The filtered solids were then resuspended for 5 minutes in 400 milliliters of wash solution and then filtered again. Three washing stages were employed for each test. After washing, the solids were dried, blended by hand, and sampled (25 g) for total uranium analysis. To investigate the influence of abrasion or size reduction, a pretreatment was used which consisted of milling the soil sample with 200 milliliters of extraction solution in a ceramic jar mill with 2 cm ceramic balls. After milling for 30 minutes, the slurry was wet sieved (to remove ceramic balls) into the glass resin kettles for leaching with the other 200 milliliters of extraction solution.

The results of the low solution-to-soil ratio testing (Tables 3-14 through 3-16) are as follows:

1) The leaching of uranium from the incinerator soils appears to be more dependent on time and temperature when compared to that of the storage pad soil (e.g., increasing extraction time from 4 to 23 hours increased uranium removal from 38 to 80 percent for incinerator soils, but had no influence on the storage pad soil. Also, increasing the temperature from 22 to 40 degrees C (at a 2- to 4-hour leaching time) increased the uranium removal from a range of 40 - 50 percent to approximately 80 percent for incinerator soils, but had no influence on the storage pad soil.

2) Increasing the temperature from 40 to 60 degrees C had little influence on uranium removal from either soil.

Table 3-14 - The Influence of Pretreatment, Temperature, and Time on Leaching of Uranium from Soil near the Fernald Waste Incinerator (A-14) Using Sodium Carbonate Extractions

Pretreatment	Temperature (C)	Time (hr)	Uranium in Residual[a] (μg/g)	Fraction of Uranium Leached (%)
None	22	2	238	49
None	22	4	290	38
None	22	6	95	80
None	22	23	95	80
None	40	2	78	83
None	40	4	88	81
None	40	6	14	97
None	40	23	112	76
None	60	2	148	68
None	60	4	106	78
None	60	6	70	85
None	60	23	63	87
Pulverized	60	23	74	84
Milled	60	23	49	90

[a]Initial uranium concentration was 470 μgU/g of soil.

Table 3-15 - The Influence of Pretreatment, Temperature, and Time on Leaching of Uranium from Soil near the Fernald Plant 1 Storage Pad

Pretreatment	Temperature (C)	Time (hr)	Uranium in Residual[a] (μg/g)	Fraction of Uranium Leached (%)
None	22	2	68	82
None	22	4	56	86
None	22	6	71	82
None	22	23	59	85
None	40	2	32	92
None	40	4	54	86
None	40	6	44	89
None	40	23	40	90
None	60	2	46	88
None	60	4	56	86
None	60	6	30	92
None	60	23	37	91
Pulverized	60	23	39	90
Milled	60	23	31	92

[a]Initial concentration was 387 μgU/g of soil.

Table 3-16 - Removal of Uranium from the Fernald Soils Using a Citrate/Dithionite Extraction

Soil	Uranium (μg/g soil)		Fraction of Uranium Leached (%)
	Initial	Residual	
Plant 1 Storage Pad (B-16)	387	12	97
Waste Incinerator (A-14)	470	37	92

3) Pretreatment, by pulverizing and milling the samples, coupled with long leaching times (23 hours), and elevated temperatures (60 degrees C) did not release additional uranium.

4) High leaching efficiencies (greater than 85 percent removal rates) were achieved in all treatments for the storage pad soil.

5) Maximum removal of uranium from storage pad soil was 92 percent at 40 degrees C and leach time of 2 hours. Uranium in clean soil was 32 $\mu g/g$.

6) The CBD procedure produced the most effective leaching rates (greater than 90 percent for both soils). This extraction procedure uses sodium dithionite ($Na_2S_2O_4$) with a sodium citrate/$NaHCO_3$ buffer (pH=7.3) and elevated temperatures (75 - 80 degrees C) to generate a high reducing effect that reduces noncrystalline iron (III) to iron (II), which is readily chelated by the citrate and removed from the soil's surface. After reaction with the dithionite at elevated temperatures, an excess of $KMnO_4$ was added to oxidize any uranium (IV) to the uranium (VI) form followed by extraction as the carbonate complex.

3.2.1.2 High Solution-to-Soil Ratio

In the case of high solution-to-soil ratio, the design was used to investigate the influence of carbonate and citrate concentrations at varying pH on removal of uranium from the contaminated soil. Twenty grams of soil were extracted in 200 milliliters of extractant using a rotary extractor rotating at 50 revolutions per minute (rpm). After each extraction period, the pH of the soil suspension was recorded and the liquid phase was separated from the solid phase through centrifugation for 45 minutes at 2,400 rpm. Aliquots of supernatant were removed and acidified to a pH of less than 2 using ultra pure nitric acid, and sent to the analytical laboratory for uranium analysis.

1) Carbonate Leaching Tests

To test the influence of carbonate and pH on the extraction of uranium, a factorial designed experiment using three levels of total carbonate/bicarbonate (0.10, 0.25, and 0.5M) at three pH levels (8, 9, 10) and two replicates were conducted. These were 4-hour tests conducted with 200 milliliters of extractant and 20 grams of soil in a rotary extractor.

2) Citric Acid/Citrate Leaching Tests

To test the influence of citrate and pH on uranium extraction, a factorial designed experiment using three levels of total citrate (0.10, 0.25, and 0.5M) at four pH levels (unadjusted, 5, 7, and 9) and two replicates were conducted. These were 4-hour tests conducted with 200 milliliters of extractant and 20 grams of soil in a rotary extractor.

3) Bisequential Citric Acid/Carbonate Leaching Tests

A bisequential leaching test was conducted by first leaching the soils with 0.1M citric acid (20 grams of soil in 200 milliliters) followed with two (200 milliliters) extractions with 0.1M sodium carbonate/bicarbonate at pH 9. The effect of extraction time (0.5, 1, and 2 hours), and the use of $KMnO_4$ (0.02 g/g soil) in the carbonate extractions were investigated.

4) Nitric Acid Leaching Tests

To evaluate the influence of pH on the extraction of uranium in the absence of a strong chelator (such as citrate for uranium and iron), the storage pad soil was extracted with dilute concentrations of nitric acid (0.1 and 0.15M). This was done by adding concentrated, ultra pure nitric acid to a suspension of 20 grams of soil in 200 milliliters of water to a pH of 2.0 before extraction in the rotary extractor. A control using 20 grams of soil in 200 milliliters of deionized-distilled water was also carried out. Both of these treatments were conducted in triplicate.

5) Citrate-Bicarbonate-Dithionite (CBD) Leaching

The CBD pretreatment was employed to remove coatings of amorphous sesquioxides of iron and aluminum and to expose uranium. The method was used at near neutral pH and at an elevated temperature (50 - 80 degrees C). In this method, 0.3M trisodium citrate (1-3 milliliters/gram of soil), which acts as a chelating agent, was added to 200 grams of soil. Sodium bicarbonate (20 grams) was used for pH buffer control. When the soil slurry was at the required temperature and the pH was about 7.3, sodium dithionite was added in increments to reduce ferric iron to ferrous iron. This reaction was rapid and took only 15-30 minutes to complete. An excess of sodium dithionite was used in preliminary testing (150 kilograms per metric ton). Further studies are planned.

The reaction was exothermic and some sulfur dioxide escaped from the hot solution. The hot slurry was quickly filtered at a temperature of above 50 degrees C to avoid loss of iron or uranium due to co-adsorption or occlusion in other precipitates formed during cooling. The solids were washed in two stages with carbonate-based solution to remove traces of iron and uranium. The soil after CBD treatment was subjected to carbonate leaching.

6) Attrition Scrubbing Tests

The main objective of attrition scrubbing is to enhance the rate of uranium removal from soils at high pulp densities (50-70 percent solids). Abrasion removes the weathering products (i.e., iron and manganese oxides) from the soil surfaces, thus facilitating contact between leachant and uranium.

A Denver bench-top attrition scrubber was used for these tests. Five-hundred grams of air-dried soil were leached with 400 milliliters of leachant. Attrition times of 3, 5, and 15 minutes were used with four different leachants: (1) distilled water, (2) 0.5M carbonate/bicarbonate solution, (3) 3.13M citric acid solution, and (4) 0.84M ammonium carbonate/ammonium bicarbonate solution. One molar H_2SO_4 and 2.5M H_2SO_4 were also used, but only at a 15-minute attrition time. The pH of the mixed soil slurry was measured after attrition scrubbing. A portion of the soil mixture was centrifuged and the supernatant was acidified with concentrated nitric acid to a pH ≤ 2. All the acidified supernatants were analyzed for uranium.

Particle size analysis was performed on all soil material that underwent 15-minute attrition scrubbing to determine the effect of attrition scrubbing and/or leachant on particle size distribution.

The results from the high solution-to-soil ratio testing are as follows:

1) Carbonate Leaching Tests
   - (1) Removal efficiency ranged from 75 to 87 percent for the storage pad soil and there appeared to be little influence with respect to total bicarbonate and carbonate concentrations or pH.
   - (2) Removal efficiency ranged from 40 to 75 percent for the incinerator soil. Increasing total bicarbonate and carbonate concentrations, and the pH appeared to improve extraction effectiveness.

The results of these studies are summarized below:

1) Carbonate Leaching Tests
   - (1) Ranged from 0.1 to 0.5 M concentrations, over a pH range from 8 to 10, leaching duration of 2-23 hours, and a temperature range from 22 to 60 degrees C.
   - (2) Maximum removal of uranium from the storage pad soil ranged from 86 to 92 percent.
   - (3) Maximum removal of uranium from the incinerator soil ranged from 80 to 90 percent.
   - (4) Increasing the extraction temperature from 22 to 40 degrees C increased uranium removal from 40 to 80 percent with 2- to 4-hour leaching times for the incinerator soil, but had no effect on storage pad soil. An increase in temperature from 40 to 60 degrees C had little influence on leaching of uranium from either soil.
   - (5) High solution-to-soil ratios were as effective as low solution-to-soil ratios.
   - (6) Citrate/dithionite followed by a carbonate extraction procedure removed 97 and 92 percent of uranium from the storage pad and incinerator soils, respectively.

2) Citric Acid/Citrate Leaching Tests
   - (1) Removed an average of 99 percent and 68 percent of uranium from storage pad and incinerator soils, respectively, with unadjusted low pH.

(2) Of the two extraction variables, pH and citrate concentration, pH was the most important.

(3) The higher concentration of citrate (0.5M compared to 0.1M) resulted in a significant increase in extraction of uranium from the Fernald storage pad soil but not the incinerator soil.

3) Bisequential Citric Acid/Carbonate Leaching Tests

Results of bisequential citric acid/carbonate leaching tests are given in Tables 3-17 through 3-19.

(1) Uranium removal from the storage pad soil ranged from 69 to 75 percent for the citric acid extraction step, 8 to 31 percent for the first carbonate extraction step, and 5 to 9 percent for the second carbonate extraction step.

(2) Uranium removal from the incinerator soil ranged from 50 to 63 percent for the citric acid extraction step, 20 to 28 percent for the first carbonate extraction step, and 3 to 5 percent for the second carbonate extraction step.

(3) Uranium extraction is time dependent and appears to be only related to the citric acid extraction step. The citric acid extraction step required less time for the storage pad soil compared to the incinerator soil.

(4) Uranium removal from the clay- and sand-sized fractions was 80 percent and 60 to 70 percent, respectively.

(5) Potassium permanganate was effective in oxidizing uranium in the larger particle ranges. It is also implied that there were higher levels of uranium (IV) in the larger rather than smaller particle ranges.

Table 3-17 - The Removal of Uranium from the Fernald Storage Pad Soil (B-16) Using Sequential Extractions of 0.1M Citric Acid and 0.1M Sodium Carbonate, pH 9.5 (with and without $KMnO_4$)

Time (hr)	Oxidant with Carbonate[a]	Percent Uranium Extracted[b]			
		Citric	1st Carbonate	2nd Carbonate	Total
0.5	None	74	14	8.5	96
	With	69	8	4.5	82
1.0	None	75	12	4.7	92
	With	73	14	3.0	91
2.0	None	69	18	6.8	94
	With	70	31	4.2	106

[a]0.017 g $KMnO_4$/g of soil.

[b]As determined by uranium measured in extracts (an average of two replicates).

Table 3-18 - The Removal of Uranium from the Fernald Incinerator Soil (A-14) Using Sequential Extractions of 0.1M Citric Acid and 0.1M Sodium Carbonate, pH 9.5 (with and without $KMnO_4$)

Time (hr)	Oxidant with Carbonate[a]	Percent Uranium Extracted[b]			
		Citric	1st Carbonate	2nd Carbonate	Total
0.5	None	49.7	23.8	4.8	78.3
	With	50.1	28.2	5.1	83.4
1.0	None	55.5	21.3	3.4	81.2
	With	58.9	24.4	4.6	87.9
2.0	None	62.6	20.0	3.8	86.2
	With	61.3	24.5	3.0	88.8

[a]0.017 g $KMnO_4$/g of soil.
[b]As determined by uranium measured in extracts (an average of two replicates).

Table 3-19 - Uranium Concentrations in the Leached Residual of the 2-Hour Sequential Citric Acid/Carbonate Extractions of the Fernald Incinerator Soil (A-14)

Size Fraction	^{238}U $\mu g/g$	Treated			
		^{238}U $\mu g/g$		Percent Leached	
		Without $KMnO_4$	With $KMnO_4$	Without $KMnO_4$	With $KMnO_4$
Whole Soil	538	136	94	75	82
Sand 2mm-53μm	1,033	416	294	60	71
Silt 53-2μm	286	91	56	68	80
Clay <2 μm	1,109	171	152	83	85

4) Nitric Acid Leaching Tests

(1) Extractions of the storage pad soils acidified to pH 2 (average pH of 5.6 after three 4-hour extractions) with nitric acid without chelants yielded about 22 percent uranium removal. Extractions with citric acid alone under similar conditions resulted in 80-90 percent of uranium removal from the same soil. This indicates that uranium removal is not due to a simple acidification relationship, but is likely due to chelation of uranium as well as chelation of amorphous iron and aluminum oxide coatings on the uranium particles.

5) Attrition Scrubbing Tests

The results of attrition scrubbing tests are given in Table 3-20.

(1) Attrition scrubbing for 3 to 15 minutes was having the same effectiveness in extracting uranium as the batch-type extractions in 4 hours. However, in the case of citric acid, the uranium recovery was only 80 percent for storage pad soil using 3 and 5 minute attrition times as compared to greater than 95 percent using 4-hour batch-type extractions.

(2) Water was not an effective leachant for uranium for either soil; the maximum recovery was 6 percent.

(3) Citric acid extracted about 50-60 percent of uranium from incinerator soil and about 70-80 percent of uranium from storage pad soil.

(4) Sulfuric acid removed 77 percent uranium from incinerator soil at 1M concentration and 89 percent at 2.5M concentration.

(5) Sulfuric acid was ineffective in removing uranium from storage pad soil at both 1M and 2.5M concentrations. The maximum uranium removal efficiency was 18 percent. This could be due to the higher carbonate content of the storage pad soil.

(6) As for carbonate extractions, SCB was more effective in removing uranium from both the soils as compared to ammonium carbonate/bicarbonate.

3.3 OU-1 MAWS Program Soil Washing Treatability Study by Lockheed

As part of the Minimum Additive Waste Stabilization (MAWS) technology demonstration program, FEMP soil characterization and soil washing studies were conducted by Lockheed Environmental Systems and Technology Company to show the economic and technical feasibility of an integrated soil waste treatment process. Vitrification and soil washing are being considered for the remediation of contaminated sludges and soils at the FEMP. Contaminated soil residues from the soil washing process will be used as a source of silica in the vitrification of sludges. This approach has two distinct advantages: (1) it reduces the cost of silica used as an additive in the sludge vitrification process, and (2) it stabilizes the contaminated soil residue.

Table 3-20 - Comparison of the Uranium Leached by Attrition Scrubbing for 3, 5, and 15 Minutes Using Various Leachants for both FEMP Soils

Leachant	**Attrition Time (min)**	**Incinerator Soil (538 mg U/kg)**	**Storage Pad Soil (446 mg U/kg)**
		Percent Uranium Leached	
Water	3	<1	5
	5	<1	6
	15	1	5
Citric Acid	3	53	81
	5	47	69
	15	65	nr[a]
1M H_2SO_4	15	77[b]	7[b]
2.5M H_2SO_4	15	89[b]	18[b]
Na_2CO_3	3	63	84
	5	37	83
	15	62	81
$(NH_4)_2CO_3$	3	43	64
	5	43	nr
	15	40	55

[a]Not reported.
[b]Average of two replicates.

This report summarized the laboratory testing methodology and data to support the design of an on-site demonstration system. The goals of the testing are to show that:

1) The washed soil residue will provide adequate silica feed to the vitrification process.

2) A cleaned soil with uranium activity below 35 pCi/g (equivalent to 52 parts per million for natural uranium) will be produced.

3) Soil will be processed at a minimum rate of 0.25 cubic yards per hour.

Additional laboratory testing is currently being performed to optimize soil washing process parameters and the results will be issued in a later report.

3.3.1 Soils Characterization

The soils used for this study came from an area just west of the Plant 1 Storage Pad. These soils were found to contain significant amounts of grass, roots, etc. that were often matted together or bound in clay lumps. The soils contained very few rocks greater than 1 inch and were frequently bound with clay lumps.

A particle size distribution and activity of each size fraction was determined. The uranium contamination was found to be distributed throughout the size fractions in amounts greater than 35 pCi/g except for the +4 mesh fraction (26.6 pCi/g). The activities of the remaining fractions (+10, +50, +100 mesh; +30, -30 micron) ranged from 162.25 to 8,363.90 pCi/g. It was noted that the large fraction of organic matter contained high activity levels relative to the other soil fractions.

The silica content of the soils was found to be most abundant (71 percent) in the -100 mesh to +30 micron fraction.

3.3.2 Physical Tests

Several physical treatment methods were examined for their abilities to (1) break up clay lumps, (2) remove organic matter from the soil matrix, and (3) wash the coarse fraction (+100 mesh).

Three de-lumping tests were performed to determine the effectiveness of breaking up the clay lumps and liberating the organic matter from the soil matrix without shredding the organic matter. The first and second tests were performed in an agitated square tank and showed that effective de-lumping was achieved in about 1-1/2 hours with gentle agitation. It was supposed that faster de-lumping would occur with more efficient mixing (i.e., by using a cylindrical tank). The third test used a drum-type cement mixer and showed that effective de-lumping was achieved in about 1/2 hour.

Screening tests were performed by pumping de-lumped slurry through vibrating and gyratory screens to find organic material removal effectiveness. The gyratory screens were found to be more effective than the vibrating screens in clearing organic material from the screens and were selected as the best of the two. A series of froth flotation tests was also performed to find organic material removal effectiveness. Significant amounts of uranium and organic material were removed; however, a significant amount of fine soil particles was also removed with the froth, thus the screening method was deemed to be the most effective.

Initial attrition scrubbing tests conducted with -4 mesh material showed that this method was ineffective in cleaning the entire -4 mesh fraction and, in addition, shredded some of the organic material. Subsequent attrition scrubbing tests with -4 mesh to +100 mesh material using 0.1M carbonate leach solution for 15 minutes at 1,500 rpm showed that the activity was reduced from 467 pCi/g to 14.7 pCi/g. Carbonate leach solutions showed higher uranium removal than water alone. Additional attrition scrubbing tests are currently being conducted.

3.3.3 Chemical Tests

Leach Tests 1, 2, and 3

The soils for leach tests 1, 2, and 3 were generated by mixing three 5-gallon samples of FEMP soils with approximately 75 gallons of water and gently agitating the mix to liberate organic matter from the soil matrix. The slurry was then fed through a 50- and 100-mesh screen. Further size separation was done using a 2-inch cyclone. A 2,000 milliliter stock sample was collected from the cyclone overflow for leach tests. Leaching experiments were performed using a 500-milliliter aliquot of stock/sample in a 1,000 milliliter beaker equipped with a magnetic stirring bar.

Ammonium bicarbonate, sodium carbonate, and potassium permanganate powders were added to the soil slurry, and the pH and temperature were recorded. Samples of leachate were taken periodically and analyzed for uranium. Total uranium concentration of the input sample was measured at 2,389 μg/g and 2,144 $\pm$ 70 μg/g using two different techniques. Results of tests 1, 2, and 3 are given in Table 3-21.

These tests showed that significant uranium removal was effected within the first 2 hours of leaching. The leach residues from tests 1 and 2 contained 231 μg/g and 117.6 μg/g, respectively, which is above the target limit. Inadequate agitation during leaching and/or inadequate washing of the leached soil residues might have contributed to the above results.

Table 3-21 - Leach Tests 1, 2, and 3

Test Number	Reagents	Temperature	KPA Analysis (RTL) of Leachate	
			Time, hour	Uranium (μg/g)
1	3.95 g NH_4HCO_3 5.3 g Na_2CO_3 1.0 g $KMnO_4$	19 C (ambient) pH: 9.3	1 3 6 8	144 146 142 162
2	7.9 g NH_4HCO_3 10.6 g Na_2CO_3 1.0 g $KMnO_4$	30 to 40 C pH: 9.11	1.5 3 6 24	188 205 217 252
3	7.9 g NH_4HCO_3 10.6 g NH_4HCO_3 1.0 g $KMnO_4$	32 to 48 C pH: 9.53	1 1.3 7 24	155 148 145 162

Leach Tests 4, 5, 6, and 7

Samples for these tests were generated in the same manner as for tests 1, 2, and 3 except that the cyclone overflow was dried and four samples (A, B, C, and D) were collected.

Tests 4 and 5 were conducted for a 12-hour period on samples A and B at 20 percent solids in the slurry at 60 degrees C using 6.7 grams of NH_4HCO_3, 8.99 grams of Na_2CO_3, and 8.49 grams of $KMnO_4$. A 4 to 1 wash to leachate ratio was used in washing the leached soil residues. Uranium concentrations in the final leached residues were above the target concentrations (52 μg/g uranium), as shown in Table 3-22.

Table 3-22 - Tests 4 and 5, Concentration of Uranium in Leached Residue

Sample	Net Weight (g, wet)	Net Weight (g, dry)	Uranium (μg/g)
A	273.1	138.1	214.4
B	262.1	136.3	203.3

The above unsatisfactory results were attributed to inadequate oxidant usage during the tests.

Tests 6 and 7 were carried out on samples C and D for an 8-hour period at 40 degrees C and 60 degrees C, respectively, at 20 percent solids using the same reagent concentrations as used in tests 4 and 5. A 4 to 1 wash to leachate ratio was used in the centrifuge wash step. The concentrations of uranium in the leached soil residues from tests 6 and 7 are given in Table 3-23.

Table 3-23 - Tests 6 and 7, Concentration of Uranium in Leached Residue

Sample	Net Weight (g, wet)	Net Weight (g, dry)	Uranium (μg/g)
C	257.8	179.9	17.0
D	275.3	169.6	11.0

Results of the above tests showed that the uranium removal goal of 35 pCi/g in the washed residue can be attained or exceeded, but only under carefully controlled oxidation potential. Target uranium concentration in the leached soil residue is achievable at 40 degrees C. Additional testing is being performed to confirm water treatment system operating parameters and to generate additional leaching kinetic data.

3.3.4 Test Results

In summary, the laboratory studies have shown that:

1) The FEMP soils have a high clay content (70 percent less than 30 micron material). Gentle agitation in a tank will be used to break up clay lumps, wash soil from rocks larger than 1 inch, and separate organic material from +100 mesh silt.

2) Organic matter makes up a significant fraction of the soil matrix and contains high levels of activity relative to other soil fractions. Even though this material could be leached, leaching costs

and chemical usage would increase significantly; therefore, this material will be sent directly to vitrification.

3) Uranium concentration is distributed throughout the soil matrix in levels above 35 pCi/g and the majority of soil particles are less than 100 microns in size.

4) Carbonate leaching at temperatures between 40 and 60 degrees centigrade is effective in achieving the 35 pCi/g criteria. The +100 mesh silt fraction will be cleaned through physical separation. The -4 mesh/+100 mesh fraction washing is enhanced using a carbonate leach solution. The fine fraction (-30 micron) will be cleaned using a carbonate leach solution.

5) The 100 mesh (149 micron) to 30 micron fraction has the highest silica content of the soil matrix. This fraction will be fed to vitrification before leaching to minimize leaching costs and chemical usage.

The results of the laboratory tests indicate that a feasible soil washing system can be designed using the following proposed operations and processes.

3.3.5 Proposed Soil Washing System

Raw FEMP soils will be fed with water to an agitated tank to produce an approximately 50 weight percent solids slurry. The slurry will pass over a weir in the tank through a single 4-mesh gyratory screen and then through 50- and 100-mesh double deck gyratory screens. The organic matter trapped by the screens will be fed to the vitrification process.

Heavy, larger material (e.g., gravel) that settles to the bottom of the slurry tank will be passed through a 1/2-inch screen prior to an attrition scrubber. The scrubbed material will be passed through double deck 50- and 100-mesh gyratory screens. The +100 mesh material will be combined with the +1/2-inch material, drummed, and verified as meeting the 35 pCi/g criteria.

The -100 mesh slurry will be combined with the -100 mesh material from the attrition scrubber and fed to a 2-inch cyclone designed for 30 micron fractionation. The cyclone underflow (+30 micron) will be fed to the vitrification process. The cyclone overflow will pass to a thickener and then to the leach system. After leaching, the soil will be fed to the centrifugal decanters to wash the leach liquor from the soils. The washed soil will be drummed and verified as meeting the 35 pCi/g criteria. The spent leach liquor will be sent to a water treatment facility and reclaimed for further soil washing.

SECTION 4

PROPOSED INTEGRATED SOIL WASHING SYSTEM

The three sets of soil washing testing results presented (ORNL, MAWS, and IT) have shown the capability to successfully remove uranium from contaminated soil, reducing the uranium concentration below the target value of 52 mg/kg. The results of the testing, along with the observations made during these testings, are used to develop the soil washing process that will be used at the FEMP.

4.1 Evaluation of Soil Washing Process

The SCB scrubbing/extracting solution is recommended for the proposed soil washing system based on the following comparisons with the other tested scrubbing/extracting solutions:

1) Mineral Acid Leachings

   Leaching of soil by mineral acid was able to reduce the uranium concentration in the soil below the target value. However, the acid extractions were more destructive to soil constituents, particularly aluminosilicate clay minerals. This destruction in the physicochemical characteristics of the soil will produce large volumes of sludge during the precipitation of uranium from the leachate. The production of this sludge is an additional waste form that will require treatment and is contrary to the philosophy of minimum waste generation. Also, large volumes of acid are used in dissolution of carbonate minerals, namely calcite and dolomite. Such reactions do not occur in alkaline leach involving sodium carbonate extractions.

2) Citrate-Bicarbonate-Dithionite with Ammonium Carbonate

   Non-crystalline iron and alumina sesquioxides are removed from the clay surfaces of the soil, and iron +3 is reduced to iron +2, which is readily chelated by the citrate. However, this extraction method produces some sludge, but far less than mineral acid extractions. Also, leaching for this system must take place at high temperatures (75 to 80 degrees C). Upon cooling to ambient temperature, sulfates precipitate from the leaching solution and entrain the uranium. To prevent this from occurring during the process, filtration must happen quickly after leaching, and at high temperatures. The citrate forms soluble complexes with the iron and aluminum, which result from the dissolution of sesquioxides. This reduces the citrate's capacity to complex uranium +4, which cannot be extracted because it precipitates out as a hydrated oxide. Another disadvantage of this system is that the quantities of citrate and dithionite required during testing were high, which would mean high operating costs for a full scale system.

3) Citric Acid/Citrate

Citric acid removes coatings of amorphous iron and aluminum sesquioxides from the soil surface, which enhances the leaching of uranium. Citric acid extraction of uranium is a pH dependent process (the best results are obtained at pH values < 3) and does not require elevated temperatures (> 40 degrees C) to get good results. However, this method removes significant quantities of iron, aluminum, calcium, and magnesium from the soil. The quantity of the acid needed to treat the soil is high due to dissolution of carbonate minerals, namely calcite and dolomite. This creates a high volume of sludge which complexes waste disposal scenarios. Also, both the quantity of acid required and the leach time (4 hours) are high.

4) Bisequential Citric Acid/Carbonate

A citric acid extraction time of only 0.5 hours yielded the same results as for a 2-hour extraction time for Fernald storage pad soil, which means that contamination is readily leachable and extraction times can be considerably reduced. However, this is a three-stage process; Stage 1 involves leaching with citric acid, and Stages 2 and 3 involve leaching with sodium carbonate. This obviously is more complex than a single-stage extraction involving acidic or alkaline leach. This complexity will result in higher capital and operating costs.

5) Sodium Carbonate

Sodium carbonate selectively leaches uranium from the soil and does not destroy the aluminosilicate minerals to the extent as the mineral acids and, therefore, does not generate a high amount of secondary waste. The tetravalent uranium is oxidized to hexavalent uranium at a faster rate compared to acid solutions, and the uranium +6 is readily leachable with sodium carbonate. A leach time of 2 hours is required because of slow reaction kinetics at a leach temperature between 40 and 60 degrees C.

All of the above systems, including sodium carbonate leaching, were able to reduce the uranium concentration in the soil below the target value. The advantages of the sodium carbonate leaching, as stated above, outweighed those of the other systems.

4.2 Soil Washing Process Development

The proposed FEMP soil washing system will incorporate a combination of physical separation techniques (screening) and chemical extraction techniques (leaching and precipitation) to remove uranium from the contaminated soil. All three groups of testing pre-screened the soil through a 3/4-inch screen before testing; the screen oversize was considered as soil having uranium levels below the target uranium level, and the screen undersize was the soil used in the actual testings. This methodology is adapted for the proposed soil washing process where the excavated soil is serially screened through a 6-inch grizzly, a 1/2-inch trommel screen, and a 4-mesh double deck screen. The oversize materials from these screens are water washed, monitored, then returned to the site as clean soil for backfill.

After the screening process, the proposed soil washing system uses a series of three reactor scrubbers (combination of attrition scrubbing and leaching) with potassium permangenate as an oxidant, along with 0.25M sodium carbonate and 0.25M sodium bicarbonate as scrubbing/extraction agents for the soil.

After leaching, the leach slurry in the proposed system is thickened and filtered, and the filter cake is returned to the site as clean soil for backfill. The resulting liquid from the thickening process and the filtrate is sent to precipitation where caustic soda is added to the fine particle slurry to precipitate uranium from the solution. The precipitation product (contaminated portion) is thickened and filtered and sent to treatment or disposal, while the resulting effluent is sent to preliminary wastewater treatment.

The results of test work discussed in the preceding sections were used as the basis for developing the process flow diagram for a full-scale soil washing system.

Process parameters used in the development of the flow diagram include:

1) The Treatment Plant capacity is 480 tons/day wet soil with 15 percent moisture content by weight.

2) Particles larger than 3 inches are expected to be clean; however, before release of this fraction, these will be rinsed with clean process water and then monitored.

3) Washing the minus 3-inch fraction in a drum washer using recycle water will be effective.

4) The plus 1/2-inch fraction of the washed soil can be released as clean soil after rinsing it with clean process water and monitoring.

5) The minus 4 mesh fraction of the soil shall be treated by leaching to remove contaminants by dissolution. Attrition scrubbers/reactors can perform this function and are preferred for the following reasons:
   (1) Surface contaminants are removed by attrition
   (2) Improves dispersion and dissolution

6) Cut-off grade for clean soil seems to be the plus 4 mesh (4.76 mm) in the soil discharged from the drum washer.

7) FEMP soil can be categorized as difficult to work due to the high percentage of fines as silt and clay (over 60 percent).

8) The removal of contaminants probably cannot be accomplished by simple washing followed by physical separation; however, this must be confirmed by additional tests.

9) To supply a suitable feed to the attrition scrubbers/reactors, a thickener is needed to produce an underflow with 35 percent solids by weight.

10) Scrubbing/leaching may be carried out with 0.25M Na_2CO_3 and 0.25M $NaHCO_3$. Sufficient oxidation using $KMnO_4$ shall be provided to oxidize uranium into a soluble state (from +4 valence to +6 valence).

11) As for the leaching conditions, agitation with 2 hours residence time at a temperature of 40 degrees C is assumed to be adequate.

12) It was assumed that, during dissolution, some portion of silica and alumina would go into solution as sodium aluminate/silicate, along with other heavy and non-ferrous metals.

13) Contaminants (radionuclides, metals, sodium-silicate, and aluminate) can be removed from the leachate by precipitation with sodium hydroxide.

14) For solid/liquid separation after leaching, treatment shall include thickening followed by filtration with countercurrent water wash on the belt filter. This is assumed to be adequate to produce a filter cake with 30 percent moisture content as clean soil.

15) Precipitates can be separated from solution by thickening followed by filtration with washing to yield a contaminated product for further treatment and/or disposal.

16) Depleted solution can be recycled after converting sodium hydroxide in the solution back into sodium carbonate by CO_2 purging.

17) A bleed to the AWWT will be used to control sodium carbonate concentration in the recycle water. Clean process water shall be used for rinsing of clean soil and to provide wash water to the filters.

Figure 4-1 is a block flow diagram depicting the proposed soil washing process.

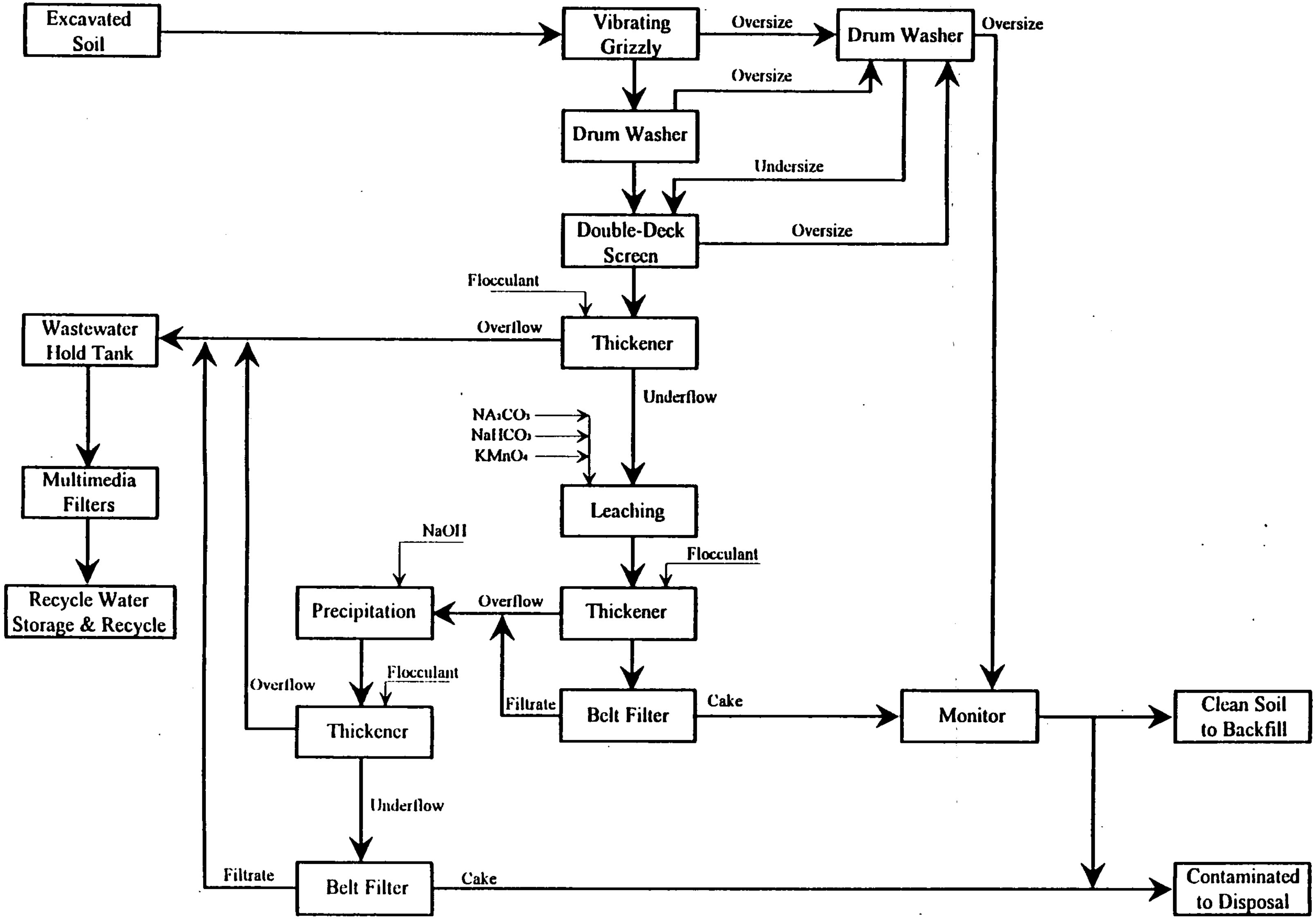

Figure 4-1 - OU-5 PO-81 Proposed Soil Washing System

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4.3 Furtments

To support Title I aawing critical tests need to be performed:

1) Feed soil padetermine fractional distribution for organics, total uranium, metal, and ra

2) Washability followed by wet screening to determine the distribution of contaminants

3) Attrition scrul flotation tests to determine contaminants removal efficiency

4) Leach testing0.5M sodium carbonate and sodium bicarbonate to optimize leach conditi
   (1) Test e solids percent, leach solution strength, temperature, and oxida
   (2) Deteration in the recycled liquor after precipitation of contaminants

5) Settling and h residues and precipitates

6) Precipitation ptimum precipitation conditions for removal of contaminants from the leac

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SECTION 5

SOIL WASHING FACILITY: CENTRAL VS. PORTABLE SYSTEM

The portable soil washing system will consist of modular, skid-mounted equipment with interconnecting piping and wiring. This design feature enables the equipment to be located at different remediation sites (or at one site convenient to all remediation sites).

A portable soil washing system would eliminate the hauling of contaminated soils from the remediation sites to a central facility and clean soils back to the originating sites. However, some or all of the contaminated soil fraction remaining after treatment will require packaging and transport to the vitrification plant. By eliminating contaminated soil hauling to the soil washing facility, transportation equipment and labor costs, FEMP traffic congestion, and the risk of spillage and spread of contamination will be reduced.

In comparison, a central soil washing facility would eliminate unproductive time and expenses involved with moving the soil washing system to different remediation sites. The items that contribute to this inefficiency include decontamination and/or packaging of equipment for transport; survey (and decontamination, if required) of former facility sites; loading, transport, and unloading of equipment; and maintenance, consumables, and breakage during disassembly and assembly of the equipment.

Two important considerations that affect either type of soil washing system are the distance between the remediation sites and the number of sites to be remediated with the system. As the distance between the remediation sites becomes larger, the portable system appears more favorable because of the reduced soil transportation costs and risks. As the number of remediation sites increases, the central facility appears more favorable because of the reduced operating and maintenance costs of the system.

With regard to the former FEMP production area (OU-3), the central facility appears more favorable than the portable system because all the remediation sites are within an area of approximately 160 acres; the working area is developed and has restricted access to the public; and the hazards and risks associated with contaminated soil transport are relatively low.

Further, the weather data for the Fernald area (rainfall approximately 40 inches per year and several snow days per year) strongly favor the installation of a central facility as compared to a portable system because a central facility will not be subject to interruptions/shutdowns due to inclement weather.

A soil washing facility which handles solids, slurries, and wet filter cake requires continuity of operations for efficient and trouble-free operations. Start-up of such plants after temporary work stoppages is problematic due to plugging of pipelines and the settling of solids in tanks and other equipment. Interruptions due to inclement weather conditions are least desirable.

Also, the projected life span of 21+ years for this facility strongly suggests a permanent central facility where the contaminated soil can be brought from several areas at the site.

However, it may be desirable to have a small (2-5 tons/hour) portable soil washing facility which can be used to wash the existing contaminated soil stockpiles at various locations at the FEMP. Apart from soil remediation, it will provide valuable technical data for full-scale operations and act as a training ground for plant personnel.

SECTION 6

SOIL WASHING SITING ALTERNATIVES

An ideal location for the soil washing facility would minimize the need for radiological screening and wheel washing control points, require the shortest site utility extensions, make maximum use of existing roads and minimize the construction of new access roads, minimize the amount of earthwork and related site preparation required, and minimize other transportation-related impacts. The soil washing facility needs to be centrally located to all of the OUs, especially OU-3 because it is the largest generator of contaminated soil. The location should not interfere with other OUs' remedial activities. The following subsections describe the evaluation of alternative locations for the soil washing facility.

6.1 Description of Evaluation Criteria

PARSONS evaluated possible locations for a soil washing facility based on the following criteria:

1) Radiological screening/wheel washing
2) Utilities
3) Road construction/improvements
4) Site preparation
5) Transportation-related impacts

6.1.1 Radiological Screening/Wheel Washing

Radiological screening and wheel washing will be required at the exit point from each controlled area to control the spread of contamination to clean areas. Due to the long-term operation of the soil washing facility, radiological screening and wheel washing can be a major cost item for the soil washing project. It is assumed that radiological screening/wheel washing will take 10 minutes for each truck (4 minutes for radiological screening and 6 minutes for wheel washing). The soil washing facility should be located where the need for radiological screening and wheel washing can be minimized.

6.1.2 Utilities

Utilities will include process water which will be recycled to and from the Advanced Wastewater Treatment (AWWT) facility, sanitary sewer, potable water, electrical, steam, and fire water. The shorter the utility route to the facility, the better.

6.1.3 Road Construction/Improvements

Transportation of contaminated and clean soil will involve a great amount of truck traffic. Truck haul roads must be two-lane asphalt roads, as a minimum. The soil washing facility should be located so as to minimize the need to construct new roads or improve existing roads.

6.1.4 Site Preparation

Site preparation includes earthwork, clearing, grubbing, and construction of a stormwater management system. The soil washing facility will encompass an area of approximately 7 acres. As a result, site preparation may be a costly item.

6.1.5 Transportation-Related Impacts

Transportation-related impacts examined for each of the three siting alternatives included:

1) Truck fleet size
2) Road usage
3) Soil washing facility utilization

The transportation analysis used a simulation model that linked the existing site roadway system to the recommended soil remediation schedule from the draft *Soil Remediation Schedule Study* (PARSONS 1993) and the proposed facility siting alternatives. The simulation was performed beginning in October 1997, and continued through November 2018.

6.1.5.1 Assumptions

A variety of assumptions were used in the transportation model. These included transportation, processing, cycle times, and other general assumptions.

Transportation Assumptions

In general, the waste pit soil was transported using the existing road that runs to the waste pit area. Trucks traveled toward the processing area, turning south on "A" street for both Alternatives 1 and 2. For Alternative 3, the soil was taken past the Solid Waste Landfill and north of the processing area.

The soil from the fly ash piles and South Field Area was transported north using both existing and some new roads for Alternatives 1 and 2. The soil was transported north from these areas, across the southern edge of the parking lot to the North Access Road for Alternative 3.

All process area soil was assumed to originate at the corner of 2nd and "B" streets. The silo soil used the same roadways as the waste pits soil.

Processing Assumptions

The soil washing facility processed 20 tons of soil per hour. The facility operated 52 weeks per year, 7 days per week, three shifts per day. All the soil delivered to the facility was placed in one stockpile. The soil was processed and placed in one of two areas; clean soil (70 percent) was added to the stockpile available for backfill and dirty soil (30 percent) was transported to the CRU-1 vitrification facility.

Cycle Times

Excavation of a 15-ton load occurred every 48 minutes whenever possible. To meet the demands of the soil washing facility, processing area soil was excavated at a faster pace. Soil was transported in 15-ton loads and assumed to be transported in roll-off boxes on the trucks. The unloading time was 4 minutes.

General Assumptions

The only other facility operating during the simulation was the CRU-1 treatment facility. This underestimates any congestion problems. The excavation of dirty soil was assumed to operate 5 days a week, one 8-hour shift per day. The input stockpile was limited to approximately 18,225 tons, and soil excavation was stopped temporarily when it reached this amount. When the stockpile dropped below this amount, excavation could continue.

6.2 Siting Alternatives

Alternative project sites were chosen based on the availability of a 7-acre parcel which did not interfere with other OUs' planned remedial activities. The three most viable siting alternatives for the soil washing facility are all in clean areas. This will minimize the cost of handling contaminated soils during construction of the soil washing facility. A stormwater management systems needed for all of the alternates. Three project siting alternatives, identified as "ALT 1", "ALT 2", and "ALT 3", are shown in Figure 6-1.

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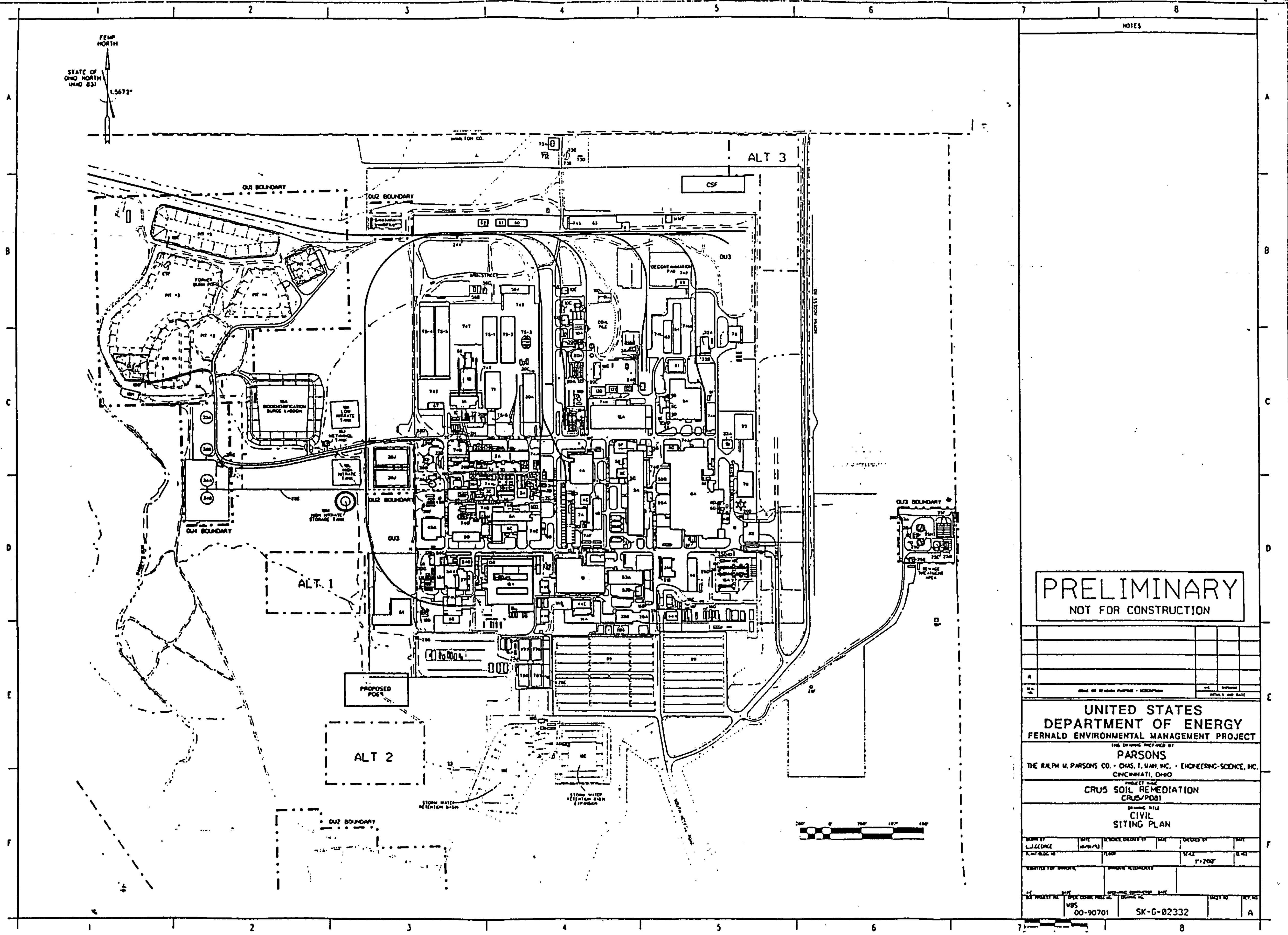

Figure 6-1 - Civil Site Plan

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6.3 Evaluation of Alternatives

6.3.1 Alternative 1

This siting alternative is located west of Building 51. At present the area is covered with dense vegetation and mature trees. A large drainage ditch, approximately 12 feet in depth, traverses the site from east to west. This area has no history of prior use from process operations. There is adequate space for future expansion.

Utilities to this area could be extended from the proposed AWWT - Phase III facility which is about 600 feet away.

This area is located adjacent to OUs 1, 3, and 4. The site could be incorporated into the controlled area to allow soil from OUs 1, 3, and 4 to be transported to and from the soil washing facility without radiological screening and wheel washing at the entry point.

Approximately 1,000 lineal feet of new two-lane road is needed to transport soil to and from OUs 1, 3, and 4. Approximately 2,000 lineal feet of new two-lane road would have to be constructed to transport OU-2 soil.

Site preparation for this alternative is extensive. Large trees and dense vegetation has to be cut. The existing 12-foot-deep ditch has to be rerouted, hence, a large volume of earthwork would be necessary.

This alternative resulted in the lowest truck fleet requirements. The truck fleet peaked in the year 2001 at nine trucks, leveling off to four after the year 2007 as shown in Figure 6-2.

Roadway usage was highest at the intersection of 1st Street and "A" Street. The number of vehicles crossing this intersection was over 380,000 between the years 1997 and 2018, or about 50 vehicles per day. This intersection was particularly busy because material from the waste pits, silos, and the processing area was transported through this area. Other busy intersections were at 1st and "B" Street (28 vehicles/day), and 2nd and "A" Street (21 vehicles/day). High road usage in the process area leads to road congestion which will negatively impact the OUs 3 and 5 remediation schedules.

This alternative involved the transportation of approximately 200,000 loads of material, including material to the soil washing facility from the excavation areas, and to the CRU-1 treatment facility from the soil washing facility. Another 81,000 loads were taken from the soil washing facility to backfill locations. Given the remediation schedule, the soil washing facility operated at 100 percent utilization. The input stockpile remained at 18,225 tons until the final month of processing.

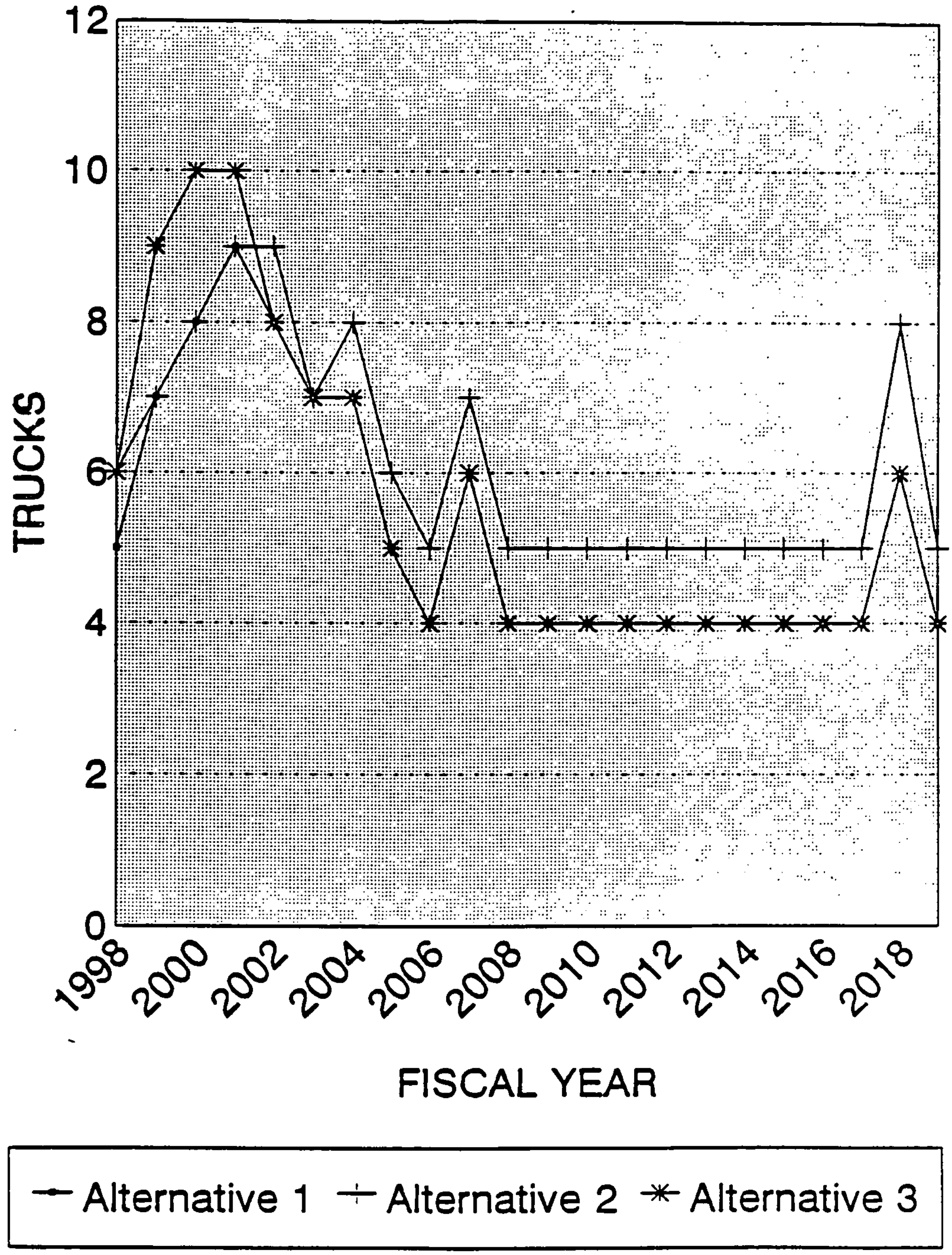

Figure 6-2 - Truck Fleet Size

6.3.2 Alternative 2

This siting alternative is located south of the proposed AWWT-Phase III facility and west of the existing Stormwater Retention Basin. The OUs 1, 3, and 4 areas are located north of this site. The nearest controlled zone is 1,000 feet north of this site. The area has not been used by any past process operations. Adequate area for future expansion is available.

This siting alternative is located too far from the OU-3 process area to include it in the present controlled area. Therefore, trucks carrying soil from all the OUs to this area will need to be radiologically screened and have vehicle wheels washed to prevent the spread of contamination.

Utilities to this area could be extended from the proposed AWWT-Phase III facility which is only about 100 feet away.

Approximately 2,300 lineal feet of new two-lane road will be required for transporting soil to and from OUs 1, 3, and 4. Approximately 400 lineal feet of new two-lane road is needed for transporting soil to and from OU-2.

Since the area is very flat, the grading effort will be minimal. Trees in this area are small and scattered. This area will need minimal earthmoving activities.

This alternative resulted in a truck fleet peak of nine trucks also, but leveled off at five trucks after the year 2007, as shown in Figure 6-2.

This alternative resulted in lower road usage in the process area because of higher usage of the roadways west of the process area. The most roadway usage was west of the proposed facility, at approximately 70 vehicles per day. The roads used were either new roads, or the existing road that runs from the waste pits towards the South Field Area. This road is a gravel, one-lane road and would require improvements to handle the projected traffic load. The busiest intersection in the process area was at 2nd and "A" Street (28 vehicles/day).

This alternative involved the transportation of approximately 200,000 loads of material, including material to the soil washing facility from the excavation areas, and to the CRU-1 treatment facility from the soil washing facility. Another 81,000 loads were taken from the soil washing facility to backfill locations. Given the remediation schedule, the soil washing facility operated at 100 percent utilization. The input stockpile remained at 18,225 tons until the final month of processing.

6.3.3 Alternative 3

This siting alternative is located at the northeast corner of the FEMP site, immediately adjacent to the OU-3 process area. OUs 1 and 4 are located approximately 1,500 feet to the west. OU-2 is located approximately 2,500 feet away. At present the area is grass covered. The area's surface has a moderate drainage pitch to the southwest. A drainage ditch is located on the west side of the site. The area is presently used for stockpiling gravel. The Central Storage Facility (CSF) is to be constructed next to this area to store contaminated soils that will later be processed at the soil washing facility. The expansion potential of this area is limited by the OU-3 boundary, the FEMP boundary, and the North Access Road.

This siting alternative could be incorporated into the OU-3 controlled area. As a result, radiological screening and vehicle wheel washing would not be required for soil transport from the OU-3 area. However, trucks transporting soil from OUs 1, 2, and 4 will need to be radiologically screened and have their wheels washed.

Extension of site utilities to this area will be a difficult and expensive task. Soil washing wastewater would have to be piped to the proposed AWWT-Phase III facility located approximately 3,500 feet away. However, process water can be supplied from the 100,000 gallon break tank in the OU-3 process area. Potable water and fire water are nearby.

Approximately 1,500 feet of new two-lane road will need to be built and approximately 1,000 feet of existing road would have to be improved for the transport of soil to and from OUs 1 and 4. OU-2 soil would be transported through the parking lot and on the North Access Road to this site.

A moderate amount of site preparation would be required for this alternative. There is a small drainage ditch, about 2 feet deep, that would need to be rerouted. There are a number of small trees. Because the area has a moderate drainage pitch, there will be a need for limited cut and fill operations to create a level area for facility construction.

This alternative resulted in the highest truck fleet peak at 10 vehicles as shown in Figure 6-2. The location of the facility requires slightly longer transport times for materials from the South Field, the waste pits and the silos, and consequently more vehicles. However, the truck fleet leveled off at four vehicles after the year 2007, similar to Alternative 1.

Road usage was heaviest north of the process area, at about 42 vehicles per day. The busiest intersections in the process area occurred where 2nd Street intersects "C," "D," and "E" Street (28 vehicles/day).

This alternative involved the transportation of approximately 200,000 loads of material, including material to the soil washing facility from the excavation areas, and to the CRU-1 treatment facility from the soil washing facility. Another 81,000 loads were taken from the soil washing facility to backfill locations. Given the remediation schedule, the soil washing facility operated at 100 percent utilization. The input stockpile remained at 18,225 tons until the final month of processing.

6.4 Conclusions and Recommendations

Table 6-1 is a comparison of the siting alternatives with regard to each evaluation criterion.

Table 6-1 - Siting Alternatives Comparison

	Alternative 1	Alternative 2	Alternative 3
Radiological Screening/ Wheel Washing	Needed only for OU-2 soils	Needed for all OU soils	Needed for OUs 1, 2, and 4 soils
Utilities	600 feet away	100 feet away	3,500 feet away
New/Improved Roads	3,000 feet	2,700 feet	2,500 feet
Road Usage	High use of Process Area roads	Lowest use of Process Area roads	High use of some Process Area roads
Site Preparation	Extensive	Minimal	Moderate
Fleet Size	9	9	10
Facility Utilization	100%	100%	100%

The three alternatives assumed that the dirty soil stockpile was limited to approximately 18,225 tons; equivalent to the CSF capacity. To meet this requirement, crews are working "on call" in the sense that they excavate material, but stop when the stockpile at the soil washing facility is at its maximum. Once the stockpile is reduced, they begin working again. This mode of operation would require coordination at the different excavation points when work is progressing simultaneously.

As an alternative mode of operation, contaminated soil could be stockpiled at the excavation points and transported from these stockpiles to the soil washing facility when the contaminated soil stockpile is below the maximum. Excavated contaminated soil would have to be covered to prevent the spread of airborne contaminants. For this option, crews begin excavating at the beginning of the year and work continuously until the excavation in that area for that year is complete. When these cases were simulated, the peak quantity of material stockpiled at the excavation sources was 57,450 tons. Utilization of the soil washing facility continued to be 100 percent and the truck fleet sizes did not change from the previous option.

To determine the recommended project siting alternative, each evaluation criterion was assigned a weighted factor representing its importance and each alternative was ranked based on how well it achieved the evaluation criteria with respect to the other alternatives (3 = best to 1 = worst). The alternative's ranking was multiplied by the criterion's importance factor to determine the alternative's score. The alternative with the highest aggregate score was chosen as the recommended project siting alternative. Table 6-2 presents the results of the quantitative evaluation.

Table 6-2 - Quantitative Evaluation of Alternatives

Criteria	**Importance**	**Alternative 1**		**Alternative 2**		**Alternative 3**	
		Rank	**Score**	**Rank**	**Score**	**Rank**	**Score**
Radiological Screening/ Wheel Washing	0.15	3	.45	1	.15	2	.30
Utilities	0.25	2	.50	3	.75	1	.25
New/Improved Roads	0.20	1	.20	2	.40	3	.60
Road Usage	0.1	1	.10	3	.30	2	.20
Site Preparation	0.15	1	.15	3	.45	2	.30
Fleet Size	0.05	3	.15	3	.15	2	.10
Facility Utilization	0.1	3	.30	3	.30	3	.30
Total Scores			1.85		2.50		2.05

Alternative 2 is the recommended project location. All trucks coming into and leaving the soil washing facility will have to be radiologically screened and their wheels washed to prevent the spread of contamination. In addition, approximately 2,700 lineal feet of new roads must be constructed. However, the cost to extend utilities to the project site and prepare the site for construction are assumed to be the lowest among the three alternatives. The vehicle fleet size required to maintain the remediation schedule is equal to, or smaller than, the alternative project sites.

SECTION 7

RECOMMENDATIONS/CONCLUSIONS

Each bench-scale test covered in this evaluation has proven that soil washing is an effective technology in removing uranium from contaminated soil. The selection of the SCB soil washing system over the others was based on simplicity of operation, minimal waste generation, absence of destructive effect on the physicochemical structure of the soil after washing, and its overall effectiveness in reducing the final soil uranium concentration to the target value of 52 mg/kg.

The data and information gathered in the bench-scale testing for the SCB soil washing system should be used for the design of the pilot plant. However, the requirements for concentrations and quantities of reagents (SCB, potassium permangenate, and caustic soda) must be fine-tuned in the pilot plant stage before the design of a full-scale system. Tests should be conducted to establish the quantities of reagents that can be returned to the process in the recycle water. So far, no data has been generated on the precipitation of uranium and other metals from leachate using sodium hydroxide. Tests should be carried out to collect this data. In addition, the process equipment proposed for the soil washing process must also be evaluated to ensure that its application is technically correct. Such process optimization will result in a streamlined soil washing facility operating at minimum cost.

In summary, the proposed SCB soil washing system is able to clean both the storage pad and incinerator soils to the predetermined specification without generating a large quantity of a complex secondary waste requiring further disposal. The SCB system is not destructive and does not remove sufficient amounts of aluminosilicate minerals from the soil, thereby leaving the soil in a sound state to return to the site as clean, usable soil.

SECTION 8

REFERENCES

(IT 1993) International Technology Corporation, April 9, 1993. *Procedures and Data of FERMCO CRU-5 Treatability Study of Fernald ID Soils*. Task 02.001.

(Lockheed 1993) Lockheed Environmental Systems and Technologies Company, January 1993. *Minimum Additive Waste Stabilization Program Soil Washing Report*. Technology Applications Division.

(ORNL 1993) Oak Ridge National Laboratory, February 1993. *Selective Leaching of Uranium from Uranium-Contaminated Soils: Progress Report 1*. ORNL: Environmental Sciences Division.

(PARSONS 1993) PARSONS ERA Project, November 1993. *Soil Remediation Schedule Study*, Draft Revision A. Fairfield, Ohio: PARSONS.

ATTACHMENT F

SAFETY ASSESSMENT (TO BE INCLUDED IN 90 PERCENT CDR)

ATTACHMENT G

MATERIAL HANDLING PLAN (TO BE INCLUDED IN 90 PERCENT CDR)